

Evaluation of an Experimental Re-Introduction of Sockeye Salmon into Skaha Lake

Year 2 of 3

Final Report
2001



DOE/BP-00005136-2

April 2002

This Document should be cited as follows:

Machin, Deanna, Karilyn Long, "Evaluation of an Experimental Re-Introduction of Sockeye Salmon into Skaha Lake", Project No. 2000-01300, 267 electronic pages, (BPA Report DOE/BP-00005136-2)

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.



Evaluation of an Experimental Re-introduction of Sockeye Salmon into Skaha Lake YEAR 2 of 3



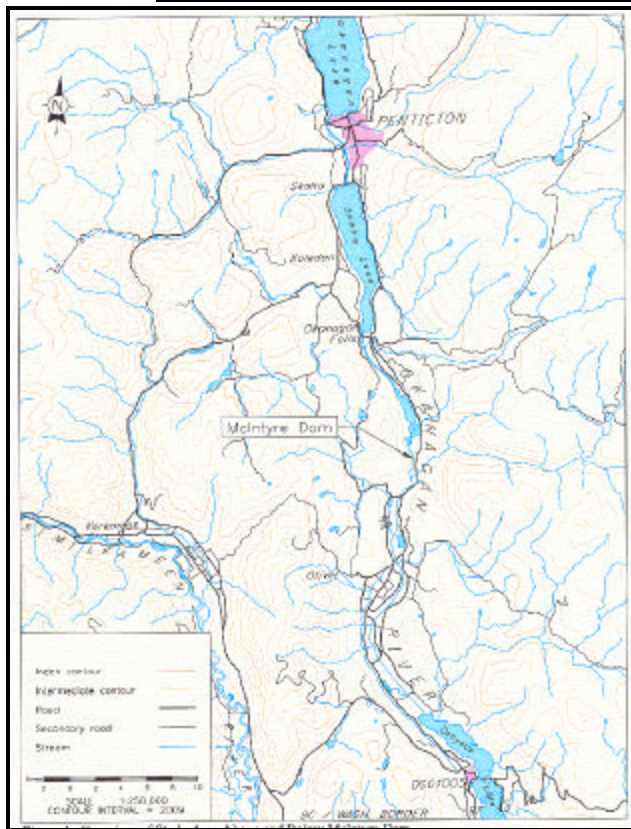
Submitted to:
Colville Confederated Tribes
P.O. Box 150
Nespelem, Washington
U.S.A. 99155

Funded by:
Bonneville Power Administration
905 NE 11th Avenue
P.O. Box 3621
Portland Oregon
U.S.A. 97208

April 2002

Submitted by:
Okanagan Nation
Fisheries Commission
3255 C Shannon Lake Road
Westbank, BC V4T 1V4
CANADA

FINAL Report



Christopher Fisher
Colville Confederated Tribes
Omak Community Center
P.O. Box 862
Omak, WA
U.S.A. 98841

April 26, 2002

Dear Chris,

**Re: Year 2 FINAL Report - Evaluation of an Experimental Re-introduction of
Sockeye Salmon into Skaha Lake**

Please find enclosed two copies of the Final Year 2 report "*Evaluation of an Experimental Re-introduction of Sockeye Salmon into Skaha Lake*". The Year 2 report is a compilation of Objectives 1, 2, 3 and fieldwork completed to provide information required to complete Objective 4 "*Lifecycle Model of Okanagan Salmonids*". Thank you for the opportunity to conduct this research.

Please contact our office if you have any questions.

Sincerely,
OKANAGAN NATION FISHERIES COMMISSION

Deana Machin
Program Manager

PREFACE

THE PROGRAM

The Okanagan Nation in Canada and tribes in the U.S. have proposed re-introducing sockeye salmon to their historic range (Figure 1). The purpose of this project is to assess the risks and benefits of an experimental re-introduction into Skaha Lake. The assessment will be accomplished by completing the following six objectives over three years:

1. Disease risk assessment;
2. Exotic fish risk assessment;
3. Inventory of sockeye salmon habitat and opportunities for habitat enhancement;
4. Development of a life-cycle model of sockeye, including interaction with resident kokanee;
5. Development of an experimental design and;
6. Finalization of a plan for re-introduction of sockeye salmon into Skaha Lake and associated monitoring programs.

Objectives 1 through 3 span the three-year period. Objective 4 was completed in the second year, and Objective 5 and 6 will be completed in the third year (see Table 1). The Okanagan Nation Fisheries Commission (ONFC) was contracted for project management and field data collection for Objectives 1, 2 and 3.



Figure 1. Overview of the Okanagan Basin

Table 1. A list of objectives, tasks and reports.

OBJECTIVE	TASKS	REPORTS		
		YEAR 1	YEAR 2	YEAR 3
1 Disease Risk Assessment	A – sample collection, diagnostic test, data entry, data analysis B - evaluate risk for developing disease or potential for introduced infectious agents C – Assess whether re-introduced sockeye interact with resident fish	<i>Disease Risk Assessment</i> Year 1	<i>Disease Risk Assessment</i> Year 2	To be completed in 2003

OBJECTIVE	TASKS	REPORTS		
		YEAR 1	YEAR 2	YEAR 3
2 Exotic Fish Risk Assessment	A –Review fish inventory information	Appendix B of <i>Exotic Fish Species Risk Assessment</i>		
	B - Inventory exotic fish species and habitat	<i>Exotic Fish Species Risk Assessment</i>	<i>Exotic Fish Species Risk Assessment</i>	To be completed in 2003
	B1 – sample predator community in the Zosel Dam tailrace		<i>Results of sockeye smolt predator sampling at Zosel Dam</i>	To be completed in 2003
	C - Complete literature review of habitat requirements for exotic species of concern	Appendix C of <i>Exotic Fish Species Risk Assessment</i>	Appendix B of <i>Exotic Fish Species Risk Assessment</i>	To be completed in 2003
	D – Assess availability of suitable habitat requirements for exotic species and likelihood of these species becoming established in Skaha Lake E - Compile information from Tasks a to d	<i>Exotic Fish Species Risk Assessment</i>	<i>Exotic Fish Species Risk Assessment</i>	To be completed in 2003
3 Inventory sockeye habitat and identify opportunities for enhancement	A - Review literature for evidence of beach or stream spawning plasticity in sockeye salmon	Appendix A of <i>Sockeye salmon habitat assessment</i>		
	B –Identify potential spawning habitat in the study area	<i>Sockeye salmon habitat assessment</i>	<i>Sockeye salmon habitat assessment</i>	
	C – Identify opportunities for sockeye habitat enhancement and development		Appendix D of <i>Sockeye salmon habitat assessment</i>	To be completed in 2003
	D – Assess potential rearing conditions in Vaseux, Skaha and Okanagan Lakes		<i>Assessment of juvenile sockeye/ kokanee rearing capacity</i>	To be completed in 2003
4 Develop life-cycle Model of Okanagan salmonids	A – Review literature on life-cycle of Okanagan Salmonids		<i>Interaction of kokanee and rainbow trout with exotic species</i>	
	B - Design document of model C – Review model structure & assumptions		Completed June 2002	
	D – Model development E – Develop user interface F – Document			To be completed in 2003

THE FUTURE

The actual re-introduction and monitoring will be described in a future work based upon decisions made after the Year 3 analyses are complete. The information contained in this plan, as well as the information gathered from the re-introduction itself, will support future decisions on rebuilding strategies for the Okanagan River sockeye stock.

FINAL

Evaluation of an Experimental Re- introduction of Sockeye Salmon into Skaha Lake

OBJECTIVE 1 Disease Risk Assessment

Submitted to: Chris Fisher
Colville Confederated Tribes

Submitted by:
Okanagan Nation
Fisheries Commission

April 2002

EXECUTIVE SUMMARY

The Okanagan Nation and tribes in the U.S. have proposed re-introducing sockeye salmon into Okanagan Lake. To investigate the risks involved, a multi-agency workshop recommended an experimental re-introduction into Skaha Lake. Risks might include competition between sockeye and kokanee, the introduction of exotic species, and the introduction of new diseases. This report summarizes the findings from the second year of a three-year disease risk assessment.

The first task was to compare the disease and infection status of fish above and below McIntyre Dam (the present limit of sockeye migration). Additional tasks included determining if lake conditions would contribute disease risks and assessing whether re-introduced fish were likely to interact with resident fish or extend the range of pathogens.

The disease agents of particular concern are:

- ◆ infectious pancreatic necrosis virus (IPNV),
- ◆ infectious haematopoietic necrosis virus type 2 (IHNV type2),
- ◆ erythrocytic inclusion body syndrome virus (EIBSV),
- ◆ the whirling disease agent (*Myxobolus cerebralis*), and
- ◆ the ceratomyxosis agent (*Ceratomyxa shasta*).

The Okanagan Nation Fisheries Commission was responsible for collecting fish from above and below McIntyre Dam, and the number of fish collected surpassed the target of 720 fish from each area. A wide variety of species was captured including sockeye, kokanee, whitefish and 13 species of non-salmonids.

Provincial and federal fish health laboratories performed the lab analyses. All of the virus isolates obtained appeared to be IHNV type I. However, IHNV type I is not a concern because it is already found above McIntyre Dam.

There was no indication of IPNV in any of the samples tested. However, another condition, indistinguishable from erythrocytic inclusion body syndrome (EIBS), and indicative of the presence of the EIBS virus, was found. Because EIBS occurred in fish above and below the Dam its causative virus is probably widespread in the Okanagan drainage.

All adult sockeye samples tested to date for the whirling disease agent (*Myxobolus cerebralis*) and the ceratomyxosis agent (*Ceratomyxa shasta*) proved negative for these pathogens. In addition live box exposures of rainbow trout susceptible to these agents failed to detect *M. cerebralis* in sites below and above McIntyre Dam. Tests for these two pathogens are continuing, not only in sockeye, kokanee and whitefish, but also using the live box exposure technique.

At this stage in the sampling, there is no evidence that the fish populations above and below the Dam differ with respect to pathogens of concern.

Limnological data for Okanagan and Skaha Lakes reveal no extraordinary risk of predisposing fish to disease. Both lakes become stratified with a warm epilimnion and a cooler hypolimnion in summer followed by an overturn. Thus salmonids should be able to reside in non-stressful oxygen and temperature conditions all year long. However, Skaha Lake, which is much smaller and shallower than Okanagan Lake, may be slightly stressful to salmonids in very warm years.

Kokanee in Okanagan and Skaha Lakes have declined drastically due to reduced nutrient input and the introduction of mysids which compete with kokanee for zooplankton. There is some speculation that sockeye would add to the competition and could adversely affect the health of kokanee because starving fish are less likely to be robust and disease resistant. However, the decomposing carcasses of the spent sockeye would provide nutrients from the sea which may mitigate any negative effects.

Sockeye progeny will likely have eco-niche requirements and behaviour patterns similar to those of kokanee. Thus cross infections are possible. Cross infections may also be possible between salmonids and non-salmonids. However the important question is whether any new pathogens are likely to be introduced. The present pathogen survey is intended to provide answers to this important question.

ACKNOWLEDGEMENTS

The culmination of this report has been a group effort and the Okanagan Nation Fisheries Commission (ONFC) would like to thank all those involved.

Dr. Trevor Evelyn and Dr. Larry Hammell have been instrumental from the outset in preparing the sampling plan and analyzing the thousands of results from the laboratories. Thanks to Sherry Guest of the Ministry of Water, Land and Air Protection (MOWLAP), Fish Culture Section Laboratory, and to Garth Traxler and Jon Richardson of Department of Fisheries and Oceans (DFO) Pacific Biological Station, Fish Health Laboratory for their invaluable work in processing the freshwater and anadromous fish samples.

Chris Fisher and Monte Miller of the Colville Confederated Tribes were a great help in making the electrofisher boat available for the night sampling of the non-salmonid fish.

Thanks to the mysis harvester Lee Granberg and the MOWLAP's Steve Matthews and David Cassidy for their considerable help collecting the kokanee fry which they otherwise try so hard to steer clear of catching.

Thanks also to Barry Hanslit of the Pacific Biological Station for his invaluable help collecting sockeye fry for disease analysis during his trawls of Osoyoos Lake.

Thanks, finally to Jason Webster and crew of Chara Consulting who collected kokanee spawners for us.

This report could not have been completed without this assemblage of resources and expertise. Thanks again to everyone involved.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF FIGURES AND TABLES.....	v
LIST OF PHOTOS	v
 1.0 INTRODUCTION	 1
1.1 Project Background	1
1.2 Project Area	1
1.3 Project Objectives	1
 2.0 METHODS	 4
2.1 Field sampling methods.....	4
2.2 Live box testing for <i>Myxobolus cerebralis</i> and <i>Ceratomyxa shasta</i>	6
2.3 Laboratory methods used by Department of Fisheries and Oceans.....	8
2.3.1 Virology	8
2.3.2 Hematology	8
2.3.3 Parasitology	8
2.4 Laboratory methods used by the Ministry of Water, Land and Air Protection ...	9
2.4.1 Virology	9
2.4.2 Hematology	9
2.4.3 Parasitology	9
 3.0 RESULTS.....	 10
3.1 Fisheries & Oceans Canada laboratory results	11
3.2 Ministry of Water, Land and Air Protection laboratory results	11
3.2.1 Whirling disease live box exposures.....	12
3.3 Age - length analysis of non-salmonids	12
 4.0 DISCUSSION OF RESULTS.....	 13
4.1. Pathogen Survey	13
4.2. Factors in the lakes likely to contribute to disease or that would maintain introduced infectious agents	15
4.3. Potential interactions between resident and introduced fish and the outcome of this with respect to extending pathogen distributions	16
 5.0 REFERENCES	 17
 APPENDIX A	Ministry of Water, Land and Air Protection laboratory results
APPENDIX B	Department of Fisheries and Oceans laboratory results
APPENDIX C	Whirling disease exposure daily temperature data and site photos
APPENDIX D	Age-length data for 2000 and 2001 sampling
APPENDIX E	Findings from year 2001 pathogen survey
APPENDIX F	Specialists Resume

LIST OF FIGURES AND TABLES

Figure 1. Overview map of the areas sampled within the Okanagan Basin.....	2
Figure 2. Disease Assessment Team Structure for YEARS 1 and 2.....	3
Figure 3. Whirling disease live box exposure sites.....	7
Table 1. Disease risk assessment, sampling plan.....	5
Table 2. Disease risk summary of sampling results.....	10
Table 3. Ages of fish sampled in 2000 and 2001.....	12

LIST OF PHOTOS

Photo 1. Processing non-salmonid fish for disease.....	4
Photo 2. Processing spawning sockeye for diseases with DFO.....	4
Photo 3. Skaha Hatchery grow-out set-up.....	6
Photo 4. Rainbow trout held for grow-out.....	6
Photo 5. WD8 – taken May 2001.....	7
Photo 6. WD6 – taken May 2001.....	7
Photo 7. WD3 – taken May 2001.....	7
Photo 8. WD1 - taken May 2001.....	7
Photo 9. Whirling disease Site 2 taken May 11, 2001.....	Appendix C
Photo 10. Whirling disease Site 4 taken May 11, 2001.....	Appendix C
Photo 11. Whirling disease Site 5 taken May 11, 2001.....	Appendix C
Photo 12. Whirling disease Site 7 taken May 11, 2001.....	Appendix C

1.0 INTRODUCTION

1.1 Project Background

This report summarizes the findings from YEAR 2 of a three-year disease risk assessment. The Okanagan Nation Fisheries Commission (ONFC) and the Colville Confederated Tribes (CCT) are investigating the risks involved in re-introducing sockeye salmon into Skaha Lake, part of their historical range (Ernst and Vedan 2000).

The disease risk assessment compares the disease and infection status of fish above and below McIntyre Dam (the present limit of sockeye migration). The disease agents identified that are of a particular concern are:

- ◆ infectious pancreatic necrosis virus (IPNV),
- ◆ infectious haematopoietic necrosis virus type 2 (IHNV type2),
- ◆ erythrocytic inclusion body syndrome virus (EIBSV),
- ◆ the whirling disease agent (*Myxobolus cerebralis*), and
- ◆ the ceratomyxosis agent (*Ceratomyxa shasta*).

1.2 Project Area

Salmonids and non-salmonids from above and below McIntyre Dam were sampled in the Okanagan Basin ranging from Okanagan Lake to Osoyoos Lake. Figure 1 shows the locations of sampling sites by the type or life stage of fish targetted. As in YEAR 1 the sampling was designed to determine if fish from below McIntyre dam are carrying infectious agents not present in fish above the dam. Data on fish pathogens collected from sockeye and other salmonids downstream of Osoyoos Lake were not available this year, however the total number of fish sampled met the the sampling plan.

1.3 Project Objectives

The project objectives are outlined below (as described in the original proposal):

1. Compare the disease and infection status of fish above and below the dam,
2. Determine if there are environmental conditions specific to the lakes in question that would either put fish at extraordinary risk for developing disease or that would maintain introduced infectious agents, and,
3. Assess the opportunity for re-introduced fish to interact with susceptible resident fish or to extend the distribution of important pathogens.
4. Additionally, it was requested at the sampling review meeting in YEAR 1 that the ages of the non-salmonid fish sampled be estimated (based on their lengths) and tabulated.

The sampling protocol was designed by Dr. Larry Hammel and Dr. Trevor Evelyn (ONFC 2001) during YEAR 1, where a multi-agency workshop of people with fish disease expertise was hosted by ONFC and CCT. After completeing YEAR 1 sampling a review of the sampling protocol was conducted during another multi-agency workshop hosted by ONFC and CCT. The ONFC conducted the field sampling with Provincial and Federal agencies conducting the lab analysis (Provincial processed non-anadromous fish and Federal processed anadromous fish). See Figure 2 for a organizations involved and the working structure.

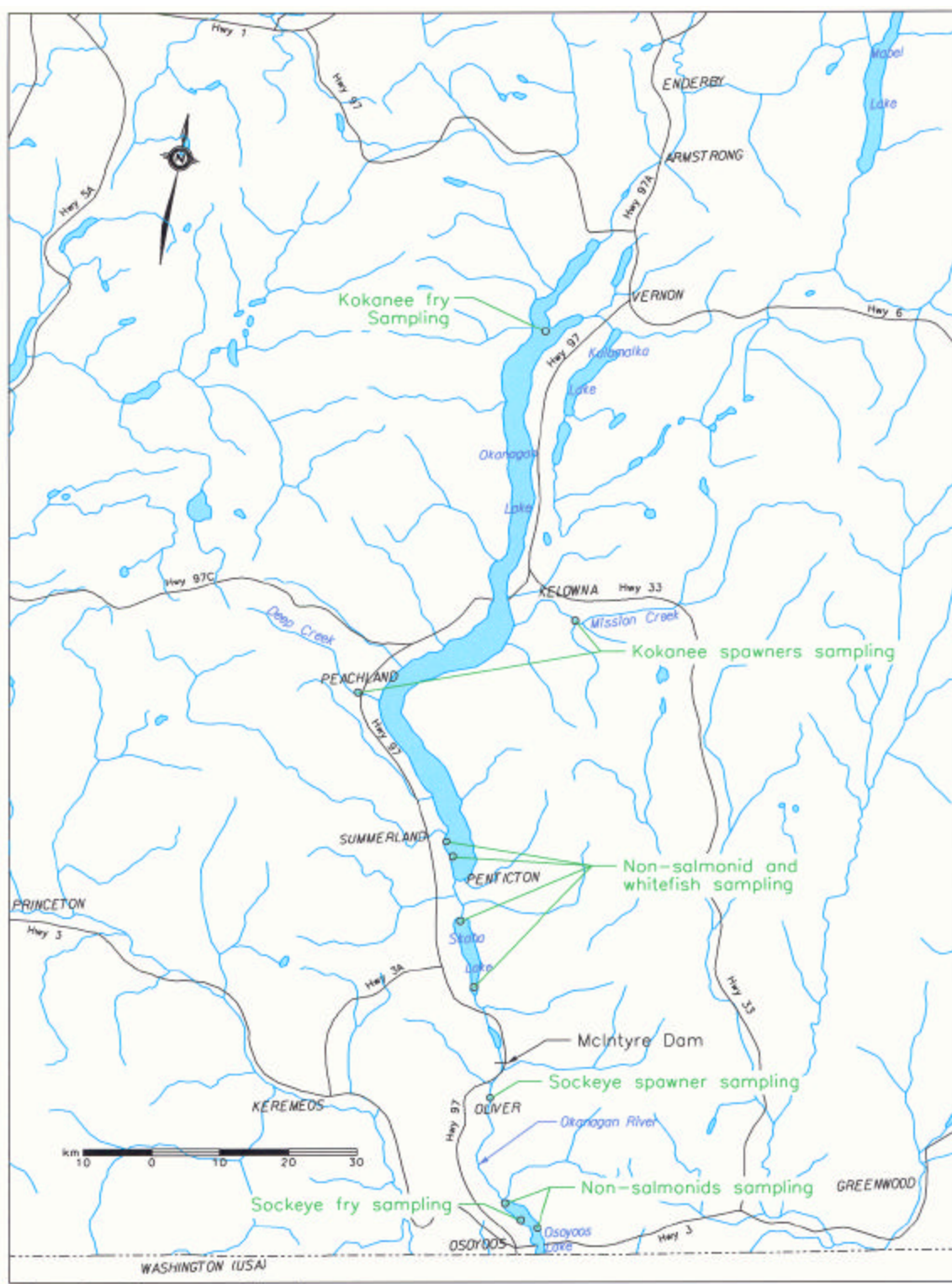


Figure 1. Overview map of the areas sampled within the Okanagan Basin

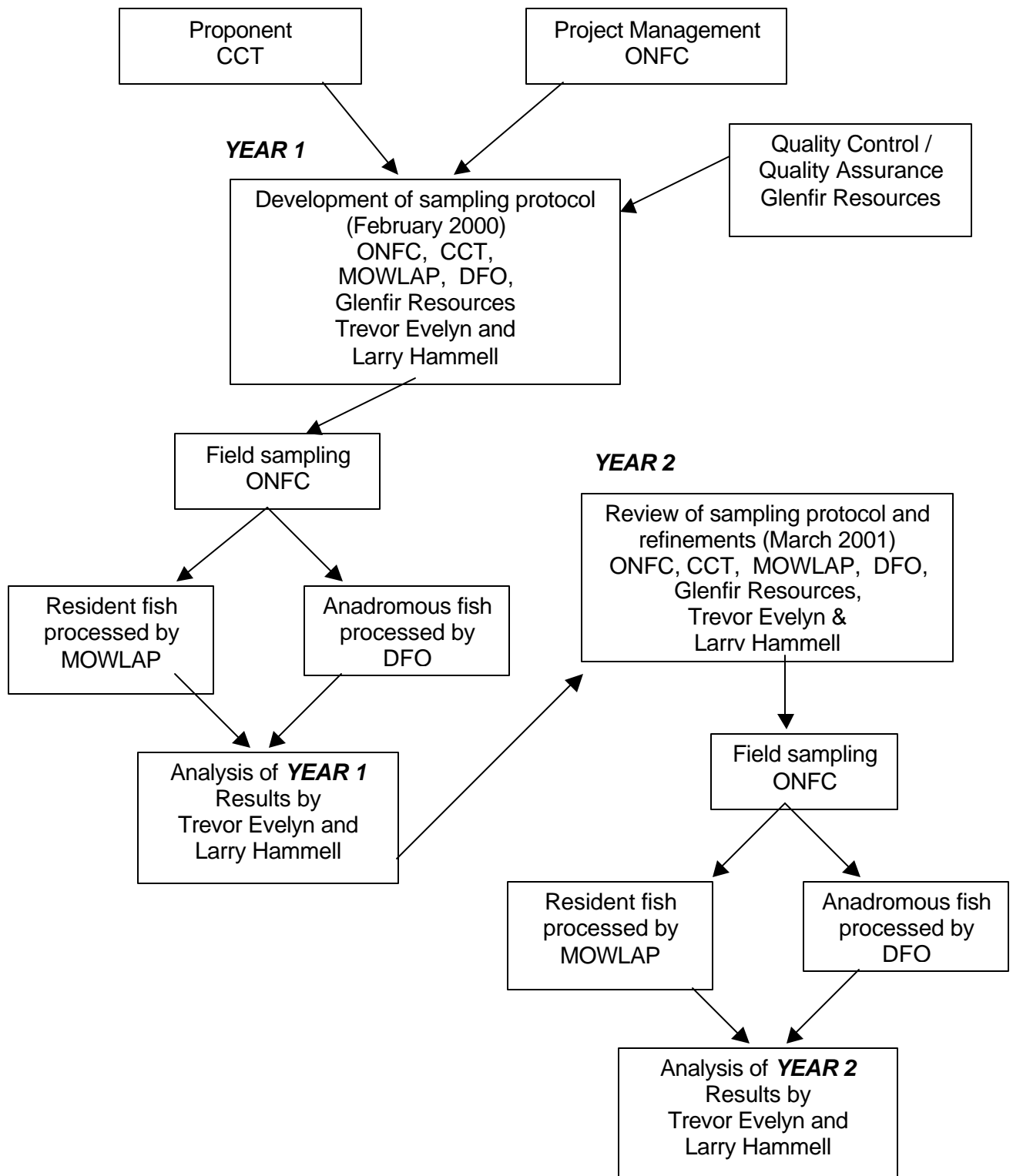


Figure 2. Disease Assessment Team Structure for YEARS 1 and 2

2.0 METHODS

After the review meeting March 1st, 2001, it was decided that the sampling protocol for YEAR 2 of the study should duplicate efforts from YEAR 1 (see Table 1) and that two sessions of *M. cerebralis*/ *C.shasta* sampling should be undertaken (spring and fall, 2001). The collection of at least 720 fish was repeated in YEAR 2 from each of the two geographic sampling regions, the sample for each geographic region to consist of at least 360 salmonids and 360 non-salmonids. Salmonids collected above and below McIntyre Dam were to feature kokanee and sockeye salmon, respectively. Non-salmonids collected from each of these regions were to represent as many species as possible with no single species accounting for more than 25% of the sample.

The sampling was to continue targeting fish likely to pose the greatest risk of introducing the disease agents of particular concern and likely to be harbouring the agents in readily detectable numbers.

2.1 Field sampling methods

Samples were collected by personnel from the ONFC and sent to the fish health laboratories. All resident salmonids and non-salmonids were sent to MOWLAP laboratory and anadromous salmonids were sent to DFO laboratory at the Pacific Biological Station. Samples were usually received the day following collection from the field.

All non-salmonids (Photo 1) were collected using a boat electroshocker at selected sites in Okanagan, Skaha and Osoyoos Lakes, as illustrated in Figure 1. The boat electroshocker was a Smith-root model 7.5 GPP, supplied by the Colville Confederated Tribes. Sockeye spawners (Photo 2) were collected on the spawning grounds in the Okanagan River by gill netting and dip netting. Sockeye fry were collected by trawling in Osoyoos Lake. The kokanee were sampled by collecting post-spawned fish on the spawning grounds of both Deep and Mission Creeks. Kokanee fry were caught by the local commercial Mysid shrimp operator in conjunction with MOWLAP at the north end of Okanagan Lake.

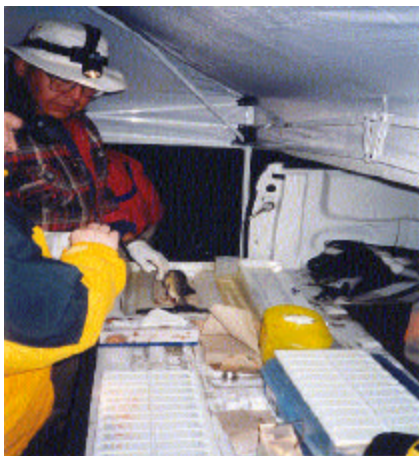


Photo 1. Processing non-salmonid fish for disease



Photo 2. Processing spawning sockeye for diseases with DFO

Table 1. Disease risk assessment sampling plan

ABOVE MCINTYRE DAM

Fish species		Laboratory Responsible	Number of fish recommended	Test for	Sampling details
Salmonids, mostly kokanee salmon	Recent post-spawners	MOWLAP	150	IPNV, IHNV, EIBSV and <i>C.shasta</i>	Make up the total with other salmonids if necessary
	2 month old fry	MOWLAP	150	IPNV, IHNV, and EIBSV	
	all ages (whitefish)	MOWLAP	60	IPNV, IHNV, and EIBSV	
Non-salmonids	Migratory & Non-migratory fish	MOWLAP	360	IPNV, IHNV and EIBSV	Collect as many species and age groups as possible from as many areas as possible. No single species should represent more than 25% of the sample.
TOTAL			720		

BELOW MCINTYRE DAM

Fish species		Laboratory Responsible	Number of fish recommended	Test for	Comments
Salmonids, mostly sockeye salmon	Recent post-spawners	DFO	180	IPNV, IHNV, EIBSV, and <i>C.shasta</i>	Make up the total with other salmonids if necessary
	2 month old fry	DFO	180	IPNV, IHNV and EIBSV	
Non-salmonids	Migratory & Non-migratory fish	MOWLAP	360	IPNV, IHNV and EIBSV	Collect as many species and age groups as possible from as many areas as possible. No single species should represent more than 25% of the sample.
TOTAL			720		

2.2 Live box testing for *Myxobolus cerebralis* and *Ceratomyxa shasta*

Testing for the presence of *M. cerebralis* and for *C. shasta* in waters above and below McIntyre Dam was based on exposing susceptible sentinel fish (rainbow trout), held in “live-boxes”, to suspect waters above and below McIntyre Dam.

In YEAR 2, ONFC was able to coordinate two sampling sessions of live-box exposures for the two above mentioned pathogens. The first live-box exposure sampling occurred May 9th to 23rd 2001 and the second exposure occurred in the fall, from October 3rd to 29th 2001. Results for the fall live-box exposures will be available July 2002 and included in the YEAR 3 report.

For the live box exposures, one thousand rainbow trout were used from a stock known to be free of *M. cerebralis* and *C. shasta*. One hundred fish in each of 8 live-boxes were exposed to the test waters and 200 fish were held as unexposed controls in Skaha Hatchery (Photos 3 and 4). The fish age was approximately 3 weeks post-hatch.

Figure 3 shows the eight sites in the Okanagan River where the live boxes were placed after water temperatures had reached 9 °C (water temperatures during exposures are found in Appendix C). The live boxes were located in areas where water flow was sluggish but the oxygen levels adequate to satisfy the needs of the live-boxed fish. Four sites above and four below McIntyre Dam were selected in low gradient mainstem locations or near the outlet of tributaries that were likely to favour the presence of the alternate hosts of *M. cerebralis* and *C. shasta* (*Tubifex tubifex* and *Manayunkia speciosa*, respectively). It is the alternate hosts that produce and shed the life-stages (TAMs) of the two parasites that are infectious for salmonids. Exposures lasted 15 to 25 days after which the fish were grown out in Skaha Hatchery for 1600 thermal units until they were processed and sent to the MOWLAP lab where testing for the presence of *M. cerebralis* and *C. Shasta* was done (see methods section). Live-box exposures will continue in 2002 with a spring and fall sampling.



Photo 3. Skaha Hatchery
grow-out set-up

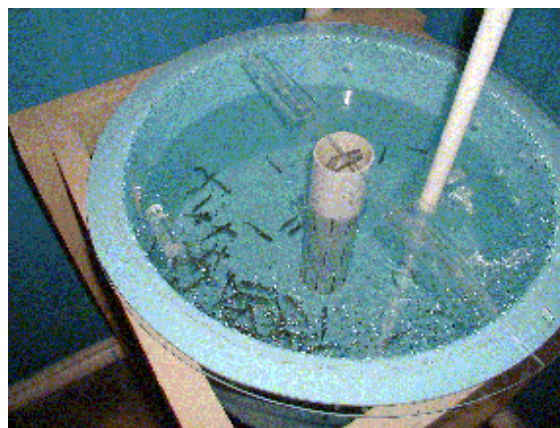


Photo 4. Rainbow trout held for grow-out

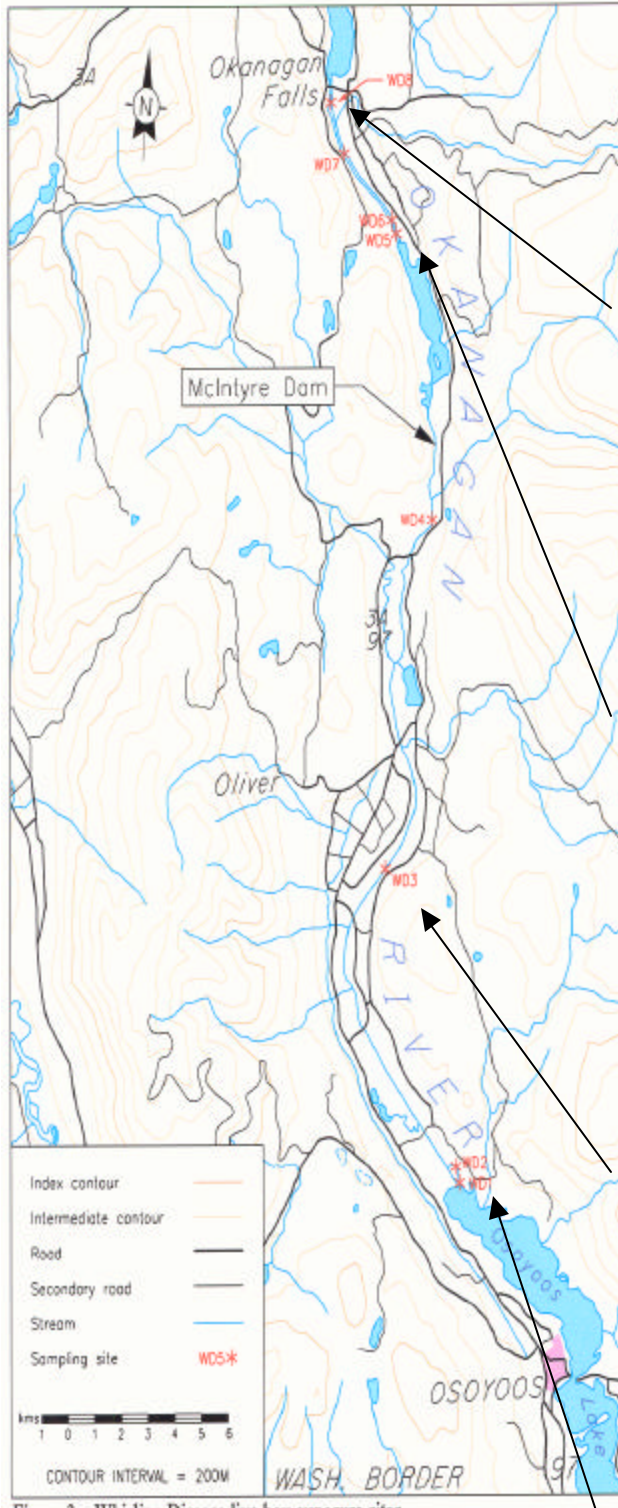


Figure 3. Whirling disease live box exposure sites



Photo 5. WD8 – taken May 2001



Photo 6. WD6 – taken May 2001



Photo 7. WD3 – taken May 2001



Photo 8. WD 1 - taken May 2001

2.3 Laboratory methods used by Department of Fisheries and Oceans

In 2001, the DFO laboratory processed sockeye fry and adults. In addition, the DFO lab processed eyed sockeye eggs, alevins and emergent fry. Samples were processed for virology within 24 hours of arrival at the DFO lab. If samples could not be processed within a period of 24 hours, they were stored at -80°C until assays were conducted. Dates of collection and assay were noted for each shipment from the field collection crew. For complete methodology, refer to the Year 1 report (ONFC 2001).

2.3.1 Virology

The majority of fish were assayed individually using the plaque assay technique in order to determine viral titers present in each fish. If pooling of any samples was done it was recorded on the summary sheets. The following tissues were assayed from the different life stages.

- Yolk sac fry (discard yolk material)
- Emerging fry - whole fish
- Fry (2-4cm) - gills plus viscera
- Adults-reproductive fluid and anterior kidney processed separately

Tissues were homogenized in Earle's balanced salt solution (EBSS) to prepare a 2% w/v homogenate. The homogenate was centrifuged at $3000 \times g$ for 10 minutes and an additional 10 fold dilution prepared to produce a 0.2% suspension. Ovarian fluid and milt were diluted 1:2 and 1:20 with EBSS. Dilutions, prepared from samples were inoculated (0.1ml) into wells containing monolayers of Epithelioma Papulosum Cyprini (EPC) and Chinook salmon embryo (CHSE) -214 cells. The cells were incubated at 15°C and observed 2-3 times per week for a period of 3 weeks for cytopathic effects (CPE).

The indirect fluorescent antibody technique (IFAT) was used to confirm the virus isolates as IHNV and to determine if any were IHNV Type II. Cell cultures infected with virus isolates from individual fish were tested with DiagXotics INHV monoclonal antibodies 14D (universal), 105B (Type II specific) and IPNV panspecific monoclonal antibody.

2.3.2 Hematology

Blood smears were air-dried and fixed with methanol for 5 minutes prior to staining with Leishman-Giemsa. Slides were examined microscopically using a 100X oil immersion lens. A minimum of 50 fields was examined for the presence of inclusion bodies indicative of EIBS.

2.3.3 Parasitology

Laboratory tests for the detection of *M. cerebralis* and *C. shasta* followed the outline in the procedures for the detection of certain myxosporidian spores as described in the Canadian Fish Health Protection Regulations: *M. cerebralis* - the pepsin/trypsin digest method; *C. shasta* - a microscopic examination of smears.

2.4 Laboratory methods used by the Ministry of Water, Land and Air Protection

The MOWLAP laboratory processed all non-salmonid fish and resident salmonid fry and adults. Samples were processed for virology within 24 hours of arrival at the Provincial Laboratory. For complete methodology, refer to the YEAR 1 report (ONFC 2001).

2.4.1 Virology

Virology methods used in YEAR 2 were consistent with YEAR 1 methods. Fish were dissected in the lab and pooled using fish of the same species, normal with normal and moribund with moribund. A maximum of three fish (majority of fish pooled in three's or lower) were pooled together. The following tissues were retained for analysis for the different life stages;

- ◆ Sac-Fry: Whole fish, after removing the yolk sac,
- ◆ Fry (2-4 cm): Retain gills, but discard head anterior to gills and tail posterior to the vent,
- ◆ Fingerlings (4-10 cm): Remove and retain the gills, gastro-intestinal tract, kidney, spleen, liver,
- ◆ Fingerlings (>10 cm): Remove and retain the gills, spleen and pyloric caeca or liver and kidney (equal amounts of anterior, middle and posterior kidney),
- ◆ Ovarian fluid: Pool females with females, males with males and post-spawners with post-spawners.

The inoculated plates were incubated for 4 weeks at 15°C and examined at least twice weekly for CPE. Virus identification as IHNV and IPNV was accomplished using the fluorescent antibody test (FAT) using monoclonal anti-sera from DiagXotics Inc. All IHNV-positive samples were tested for IPNV by FAT.

2.4.2 Hematology

Hematology methods used in YEAR 2 were the same as used in YEAR 1. Detection of EIBS was based on a microscopic examination of blood smears stained with Leishman-Giemsa (one blood smear per fish).

2.4.3 Parasitology

Detection of *M.cerebralis* was accomplished using a live-box exposure study described earlier in this document. Exposed fish were then removed to Skaha Hatchery where they were grown out for approximately 4 months to allow spore development to occur.

Laboratory tests for the detection of *M. cerebralis* were based on detecting spores of the pathogen using the Pepsin/Trypsin digest method to liberate the spores and to facilitate spore detection. Fish were pooled in groups of 5 or less within each test group. Detection of *C.shasta* is being carried out using a PCR method described by K.K. Peters Bozeman Fish Health Center, Bozeman, MT. Fish have been pooled into groups of up to three fish per pool. The *C.shasta* work is only being carried out on salmonids.

3.0 RESULTS

The field sampling season commenced in April and continued until November 2002. Below McIntyre Dam, the ONFC was able to collect all of the sockeye salmon life stages required this year plus additional samples of sockeye fingerlings (pre-smolts) and yolk sac fry. Above the dam, organizing for the collection of two month-old kokanee fry proved difficult and therefore, six month-old fingerlings were sampled instead. Table 2 illustrates the number of fish and species collected for the analysis; and indicates where, how, and when collection occurred. During YEAR 2, the focus was placed on the variety of species collected; the emphasis on collecting migratory species was dropped (see Discussion of Results section). The pathogen findings by the MOWLAP and DFO labs on the sampled fish are given in Appendix A and B respectively.

Table 2. Disease risk summary of sampling results

ABOVE MCINTYRE DAM

Fish species		Number of fish recommended	Fish Collected	Collection details	Collection times
Salmonids mostly kokanee	Recent post-spawners	150	150	Collected from Mission Creek & Deep Creek spawning channels	Sept. & Oct. 2001
	6 month old fry	150	150	Mysid shrimp harvest boat in the North basin on Okanagan Lake	Sept. & Oct 2001
	whitefish (<i>Salmonidae</i> family) various ages	60	61	Electrofishing boat collected in Okanagan and Skaha Lake	25 fish - April 7 fish - June 17 fish - August 12 fish - Nov.
Non-salmonids	prickley sculpin, red side shiner, northern pike minnow, peamouth chub, suckers, chiselmouth chub, pumpkinseed sunfish, smallmouth bass, yellow perch	360	387	Electrofishing boat collected in Okanagan and Skaha Lake	128 fish - April 143 fish - June 110 fish - August
TOTAL		720	748		

Table 2. cont. Disease risk summary of sampling results

BELOW MCINTYRE DAM

Fish species		Number of fish recommended	Fish collected	Collection details	Collection times
Salmonids mostly sockeye	Recent post-spawners	180	183	Collect from Okanagan River Channel near Oliver with DFO	Oct. & Nov. 2001
	2 month old fry	180	180	DFO - shrimp trawler in Osoyoos Lake	June 2001
	1+ sockeye fry	Undetermined	60	DFO – shrimp trawler in Osoyoos Lake	November 2001
	Yolk-sac fry	Undetermined	366	Hydraulic sampling ONFC	February 2001
	Emergent fry	Undetermined	155	Emergence fyke netting ONFC	March & April 2001
Non-salmonids	northern pike minnow, chiselmouth chub, suckers, pumpkinseed, smallmouth bass, largemouth bass, yellow perch, black crappie	360	360	Electrofishing boat	75 fish - April 95 fish – June 150 fish - August. 40 fish– Nov.
TOTAL		720	1315		

3.1 Fisheries & Oceans Canada laboratory results

The DFO laboratory processed sockeye yolk sac fry (366) and emergent fry (155) collected by ONFC in February, March and April 2001. The lab also processed 183 sockeye spawners and 180 sockeye fry (two months old), and an additional 60 yearling sockeye.

IHNV was isolated from the sockeye spawners only. Of the IHNV isolates tested by indirect fluorescent antibody labeling all were determined to be IHNV type I (none were IHNV Type II). No IPNV was isolated. Also, there was no indication of EIBSV or of erythrocytic necrosis (EN) virus, based on the observation of cytoplasmic inclusion bodies in the sockeye blood smears. Tests of the sockeye spawners for *M. Cerebralis* and *C. Shasta* proved negative for both of these pathogens (see Appendix B for details).

3.2 Ministry of Water, Land and Air Protection laboratory results

The Fish Health Unit of MOWLAP received 1,159 fish. Tests for IHNV and IPNV showed only IHNV to be present and only in kokanee spawners. Analysis of blood samples for EIBS also showed the condition to be present in non-salmonids above and below McIntyre Dam. In addition, one whitefish above the dam was EIBS positive. Tissue samples for *Ceratomyxa Shasta* testing were preserved but the results are not yet available. The lab testing form may live box exposures showed that *M. cerebralis* was not present (see Table 2 in Appendix A). Unfortunately, through an oversight, intestinal samples of the live box-exposed sentinel rainbow trout were not taken from the spring-exposed fish and thus tests on them for *C. shasta* were not possible.

3.2.1 Whirling disease live box exposures

The live box exposures testing for the presence of *M. cerebralis* and *C. shasta* were performed twice; first in the spring (May 9 to 23, 2001) and then in the fall (October 3 to 29, 2001). The temperature collected during regular checks of the live boxes are presented in Appendix C. During the spring sampling, a number of very warm days occurred which created conditions not suitable to the susceptibility of the trout to the disease. For this reason, the traps were pulled from the Okanagan River after 15 days of exposure which is short of the 25 day exposure goal we had set. The live box located at Site 7 (see Figure 3) was vandalized and all the fish released. For the duration of the exposures during the spring the temperature varied from 9 to 24 °C.

During the fall sampling water temperatures were consistently dropped over the 25 day exposure period, which was expected for this time of year. The water temperatures ranged from approximately 20° to 5 °C. Over the 25 day exposure, fish mortality was low and no vandalism occurred.

3.3 Age - length analysis of non-salmonids

It was requested at the sampling review meeting to calculate the ages of non-salmonid fish by their lengths. The results of the age-length analysis were completed and tabulated for six species where information was available (see Appendix D). The species analyzed, using data in Scott and Crossman (1973) included largemouth bass, northern pike minnow, pumpkinseed sunfish, smallmouth bass, sucker spp. and yellow perch (Table 3). Year classes of five of the six species were fairly evenly distributed over their life spans. The exception was largemouth bass which either lacked a significant amount of each age class during sampling or the growth patterns for largemouth bass in the Okanagan Basin are different from cited source. Of the 52 largemouth bass caught in 2000, 88% were less than two years old, with a similar trend in 2001. The majority of pumpkinseed sunfish (54% in 2000 and 51% in 2001) were aged two.

Table 3. Ages of fish sampled in 2000 and 2001

Age (yr)	LMB	SMB	SU	NSC	PMB	YP
0	34	47				0
1	52	47	0	4	17	38
2	13	39	0	18	48	28
3	2	32	5	13	15	24
4	2	35	22	22	6	40
5	0	15	5	14	2	65
6	0	12	23	21	3	26
7	0	7	20	15	1	0
8	0	6	8	19	0	2
9	0	1	9	6		2
10	0	0	11	8		
11	0	0	27	7		
12	0	1	15	9		
13	0	0	34			
14	0	3				
Totals	103	245	179	156	92	225

4.0 DISCUSSION OF RESULTS

4.1. Pathogen Survey

Fish sample collecting during year 2001 went off well. The sampling commenced, as planned, in February (with the collection of yolk sac sockeye) and ended in November (with the collection of pre-smolt and spawning sockeye). This year, it was therefore also possible to accomplish live box exposures for the presence of *M. cerebralis* and *C. shasta*. Two such samplings were done above and below McIntyre Dam, one in the spring and one in the fall. The only planned sampling that proved impossible, was the sampling for two month-old kokanee. Instead, we had to be satisfied with collecting six month-old specimens. Unlike in year 2000, the numbers of samples collected this year met and even exceeded the 360 fish target for salmonids and non-salmonids above and below McIntyre Dam (see Tables V, VI, VII, and VIII, Appendix E, which summarise the collections not only for year 2001 but also for year 2000).

With non-salmonids, ten species/groups were collected above the Dam and eight species/groups below (Tables V and VI, Appendix E). In year 2000, the number of fish taxa collected above the Dam also was greater than that below the Dam. A goal was to have no single species account for more than 25% of the sample. This goal was met for the non-salmonid species collected above the Dam but, again, in this year's collection of non-salmonid species below the Dam, one species (yellow perch) made up 31% (115 of 371 fish collected) of the sample and was thus over-represented (Table VI, Appendix E). To avoid such an outcome in the final year (2003) of sampling, it will be necessary to stop collecting this abundant species when 90 specimens (i.e., 25% of 360 fish target) have been caught. In addition, because last year's sample of non-salmonids below the Dam was short of the 360 fish target by 71 fish, some effort should be made to make up for this shortfall in year 2003. Taking into account the numbers of non-salmonids collected below the Dam in years 2000 and 2001, we are currently 60 fish short of the two year target of 720 fish (See Table VII, Appendix E).

With the non-salmonid species, an unforeseen problem has been in deciding which species are migratory and which are non-migratory (i.e., which species are most likely to migrate up the Okanagan drainage once the barriers to migration have been removed). This is an important consideration, because the sampling plan called for 75% of the non-salmonids collected to fall in the migratory category. It has not been possible to achieve consensus on this question, and thus the 75% target for migratory species is being dropped. Interestingly, however, if the species/groups collected below the Dam to date are rated as active migrators on the basis of their known ability to migrate upstream to spawn or on the ability to live in lotic situations (see Scott and Crossman, 1973), 70% of the fish sampled to date (or 54.5% of the species/groups sampled to date) would have been rated as potentially migratory (see Table VII, Appendix E). Even sculpins would have qualified as migratory. How many of the species would qualify as "jumpers" is another relevant question, particularly as it appears likely that some form of barrier permitting the migration of sockeye but not of walleye would have to be put in place. Walleye occur downstream of McIntyre Dam but have yet to reach Osoyoos Lake. Because of their piscivorous nature, their presence in Osoyoos Lake and in the watershed above Osoyoos Lake would be contraindicated.

A final problem with the non-salmonid sampling program is that species of non-salmonids known or suspected to be present below the Dam were again not represented in the year 2001 catch. For example, tench, which are reported to occur below the Dam, were not captured. It seems likely that the sampling methods used and the locations sampled should have shown their presence. It is possible, therefore, that tench occur in relatively low numbers below the Dam and that this explains their absence in our samples.

Based on the results obtained from the fish samples processed in 2001, only one known viral fish pathogen (IHNV, probably type I) was isolated (see Tables I and II, Appendix E). The identification protocol indicates that the IHNV isolates were not type II but it did not rule out the possibility that they were type III. This possibility is, however, discounted as remote because type III is usually found in chinook salmon and its range is in southern Oregon and northern California. IHNV type I is not one of the "pathogens of concern" because it is already known to occur in salmonids above McIntyre Dam. In this survey, it occurred in salmonid samples obtained both below and above McIntyre Dam and was detected, not unexpectedly, in fish at the spawning and post-spawning stage. The virus was not detected in juvenile salmon, not even in yolk sac and emergent sockeye fry, probably indicating that the virus is not vertically transmitted. Interestingly also, eight whitefish collected in spawning condition proved negative for the virus, leaving open the question about the susceptibility of this salmonid to IHNV.

In 2001, EIBS was again found in fish sampled from above and below McIntyre Dam, confirming the findings obtained in year 2000. In 2001 the condition was detected in one salmonid (a whitefish) and six species of non-salmonids (Tables I, III, and IV, Appendix E). In year 2000, it was found in all three species of salmonids tested and in seven species of non-salmonids. In all species, the inclusion bodies were indistinguishable from those caused by the EIBSV but it is impossible to conclude at this stage whether the etiologic agent is in fact EIBSV. If a single virus is involved, it must have a wide host range. In any event, because the inclusion body syndrome occurs in fish above and below the Dam, it would appear to be already widespread in the Okanagan drainage. For this reason, sampling for this syndrome in 2003 would seem to be unnecessary and will not be done.

In year 2001, all sockeye tested for *C. shasta* and *M. cerebralis* proved negative for these pathogens (Table I, Appendix E). A similar result was obtained for sockeye collected in year 2000. Results for *C. shasta* testing of kokanee and whitefish collected in years 2000 and 2001 have been delayed by an equipment failure but they should be ready for the YEAR 3 report. Testing for *M. cerebralis* in 2001 using live box-exposed rainbow trout also failed to detect the pathogen in fish exposed in spring to waters below and above McIntyre Dam (Table 2, Appendix A). Results for the fall 2001 live-box exposures should be available in next year's report as should the results of spring and fall exposures planned for 2003. A better idea of whether *M. cerebralis* and *C. shasta* occur in the two regions being sampled will have to await the outcome of all of the planned sampling. In the mean time, neither of these pathogens has been detected in any of the fish tested in the two sampling regions.

At this stage of the pathogen survey, there is no evidence to indicate that the fish populations above and below the Dam differ with respect to the “pathogens of concern” that they carry. If the infection status of the populations has not changed by the end of the three years of sampling, a decision on whether to allow the barrier to fish migration to come down will likely have been based more on the non-disease impacts that the sockeye (and other unintended) introductions might have.

4.2. Factors in the lakes likely to contribute to disease or that would maintain introduced infectious agents

An examination of limnological data for Okanagan and Skaha lakes reveals no obvious environmental factors likely to pose an extraordinary risk of causing disease in salmonids or non-salmonids. Both lakes appear to undergo the classic stratification cycle for northern lakes, with a warm epilimnion and a cooler hypolimnion in summer followed by an overturn. Temperature regimes in the lakes are such that salmonids should be able to reside in water of non-stressful temperatures all year long. Brief entries into the epilimnion, for feeding, even during its warmest periods (where temperatures may be less than ideal for salmonids), are not likely to be stressful enough to cause disease because they are unlikely to induce chronic stress, the type of stress most conducive to disease. Likewise, oxygen concentrations in the hypolimnion appear normally to be at levels that are non-stressful to salmonids, although in Skaha Lake, which is much smaller and shallower than Okanagan Lake, oxygen concentrations in the hypolimnion may decline to levels that may be slightly stressful to salmonids in very warm years.

Populations of kokanee in the above lakes have declined drastically ever since anthropogenic nutrient input into the lakes was reduced and mysids, competitors for zooplankton needed by kokanee, were introduced. One might speculate, therefore, that the introduction of sockeye to these lakes would add to the competition for an already limiting food supply. Because starving fish are not likely to be as robust and disease resistant as well-fed fish, one might predict that the introduced sockeye would contribute to the poor health of kokanee and other fish in the lakes depending on zooplankton for their food. However, introduced sockeye will also be providing the lakes with nutrients brought back from the sea in the form of spawning sockeye adults. Once sockeye returns to their earlier healthy levels, these nutrients, released from the decomposing carcasses of the spent sockeye, may mitigate and perhaps even neutralise any negative effects resulting from the “extra (sockeye) mouths to be fed”.

It is probably a given that any microbial fish pathogen introduced above the McIntyre Dam with sockeye or other fishes that are allowed to migrate there, will eventually establish infections in resident fish, if not disease. Most microbial pathogens are not highly host-specific, but rather can infect a variety of fish species. In addition, once released from infected fish, most of these pathogens can survive in water for significant periods. The virus responsible for IPN, for example, has a particularly wide host range, and its long-term persistence in water has been well documented. In addition, IPNV is considered to be a vertically transmitted pathogen (i.e., it can be transmitted from parent to progeny via the egg). It thus has the ability to persist in generation after generation of any introduced species, which can then serve as a constant potential source of infection for other fish sharing the same water.

With myxosporidian pathogens such as *M. cerebralis* and *C. shasta*, their persistence in a system following introduction is dependent on whether their alternate hosts are also present in the system. At the moment, it is not known if the alternate hosts for these pathogens occur in the Okanagan drainage. However, in the case of *M. cerebralis* its persistence would not be unexpected as its alternate (non-fish) host is known to be rather ubiquitous. Less is known about the distribution of the alternate host of *C. shasta* and so its chances for persistence following introduction above McIntyre Dam are more difficult to predict.

4.3. Potential interactions between resident and introduced fish and the outcome of this with respect to extending pathogen distributions

It seems very likely that the progeny of introduced sockeye will have the very similar eco-niche requirements as resident kokanee and that their behaviour patterns will be very similar. It follows, therefore, that this will increase the chances of interactions between these fishes, thus increasing the chances that any pathogens carried by one or other of these fishes will cause cross infections. These factors will likely also hold true for cross infections between introduced and resident non-salmonid species. In addition, because of the survival of many microbial fish pathogens in water, cross infections between salmonids and non-salmonids will also be possible (e.g., with IPNV). Range extensions of fish pathogens are therefore a distinct possibility when fish carrying exotic pathogens move into new areas. However, in the present study, the important question is whether any new (i.e., exotic) pathogens are likely to be introduced. The present pathogen survey is intended to provide answers to this important question.

Conclusion

At this stage in the sampling, there is no evidence that the fish populations above and below McIntyre Dam differ with respect to pathogens of concern. Nor is there any indication that Okanagan and Skaha Lakes pose an extraordinary risk of causing disease in fish. Competition between kokanee and sockeye could conceivably add to a starvation problem which would make resident fish less robust and more susceptible to disease, but nutrients from decomposing sockeye carcasses may mitigate any such negative effects. It seems likely that any exotic pathogen introduced above McIntyre Dam by fish migrating from below the Dam would likely persist in its new location and over time lead to infections (and perhaps even disease) in fish above the Dam. It is important, therefore, that the barrier to fish migration from Osoyoos Lake into Skaha and Okanagan lakes be maintained until firm conclusions are possible about the pathogens present in fish above and below the Dam.

5.0 REFERENCES

- ONFC. 2001. Evaluation of an experimental re-introduction of sockeye salmon into Skaha Lake, Objective 1: Disease Risk Assessment. Submitted by the Okanagan Nation Fisheries Commission: Westbank, B.C.
- Ernst, A and A. Vedan. 2000. Traditional Ecological Knowledge report of the Fisheries in the Okanagan Basin. Okanagan Nation Fisheries Commission: Westbank, B.C.
- Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada, Bulletin 184. Fisheries Research Board of Canada. Ottawa: Canadian Government Publishing Centre.

APPENDIX A

Ministry of Water, Land and Air
Protection Laboratory Results

Table 1. Results of MOWLAP virology and hematology

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3001	22-Apr	Okanagan Lk	WF	25.7	imm	F	neg	neg	3001		no slide
3002	22-Apr	Okanagan Lk	WF	31.5	imm	M	neg	neg	3002	0	
3003	22-Apr	Okanagan Lk	WF	30.0	imm	M	neg	neg	3003	0	
3004	22-Apr	Okanagan Lk	WF	31.0	imm	F	neg	neg	3004	0	
3005	22-Apr	Okanagan Lk	WF	29.0	imm	M	neg	neg	3005	0	
3006	22-Apr	Okanagan Lk	WF	32.2		F	neg	neg	3006	0	
3007	22-Apr	Okanagan Lk	WF	22.4	imm	F	neg	neg	3007	0	
3008	22-Apr	Okanagan Lk	WF	15.1	imm		neg	neg	3008	0	immature cells
3009	22-Apr	Okanagan Lk	WF	23.2	imm		neg	neg	3009		no slide
3010	22-Apr	Okanagan Lk	WF	30.9	imm	M	neg	neg	3010		no slide
3011	22-Apr	Okanagan Lk	WF	27.0	imm	F	neg	neg	3011		no slide
3012	22-Apr	Okanagan Lk	WF	20.5	imm	F	neg	neg	3012		no slide
3013	22-Apr	Okanagan Lk	WF	20.1	juv		neg	neg	3013		no slide
3014	22-Apr	Okanagan Lk	WF	15.4	juv		neg	neg	3014		no slide
3015	22-Apr	Okanagan Lk	WF	14.3	imm		neg	neg	3015		no slide
3016	22-Apr	Okanagan Lk	WF	37.5		F	neg	neg	3016		no slide
3017	22-Apr	Okanagan Lk	WF	29.1	imm	F	neg	neg	3017		no slide
3018	22-Apr	Okanagan Lk	WF	25.7	imm	M	neg	neg	3018		no slide
3019	22-Apr	Okanagan Lk	WF	21.6	imm		neg	neg	3019		no slide
3020	22-Apr	Okanagan Lk	RSC	7.4	imm	F	neg	neg	3020		no slide
3021	22-Apr	Okanagan Lk	RSC	7.6	imm	F	neg	neg	3021		no slide
3022	22-Apr	Okanagan Lk	RSC	8.8	imm	F	neg	neg	3022		no slide
3023	22-Apr	Okanagan Lk	NSC	10.3	imm		neg	neg	3023		no slide
3024	22-Apr	Okanagan Lk	RSC	10.0	imm	F	neg	neg	3024		no slide
3025	22-Apr	Okanagan Lk	RSC	10.2	imm	F	neg	neg	3025		no slide
3026	22-Apr	Okanagan Lk	RSC	9.8	imm	M	neg	neg	3026	0	
3027	22-Apr	Okanagan Lk	RSC	7.9	imm	F	neg	neg	3027	0	
3028	22-Apr	Okanagan Lk	RSC	7.8	imm	M	neg	neg	3028	0	
3029	22-Apr	Okanagan Lk	RSC	9.9	imm	F	neg	neg	3029	0	
3030	22-Apr	Okanagan Lk	RSC	9.3	imm	M	neg	neg	3030	0	
3031	22-Apr	Okanagan Lk	RSC	7.4	imm	M	neg	neg	3031	0	
3032	22-Apr	Okanagan Lk	RSC	9.9	imm	M	neg	neg	3032	0	
3033	22-Apr	Okanagan Lk	RSC	6.8	imm	F	neg	neg	3033	0	
3034	22-Apr	Okanagan Lk	RSC	7.5	imm	M	neg	neg	3034	0	
3035	22-Apr	Okanagan Lk	RSC	8.5	imm	M	neg	neg	3035		no slide
3036	22-Apr	Okanagan Lk	RSC	7.3	imm	M	neg	neg	3036	0	
3037	22-Apr	Okanagan Lk	RSC	8.5	imm	M	neg	neg	3037	0	only a few fields could be read
3038	22-Apr	Okanagan Lk	RSC	6.2	imm	F	neg	neg	3038	0	
3039	22-Apr	Okanagan Lk	RSC	7.3	imm	M	neg	neg	3039	0	Ghost cells
3040	22-Apr	Okanagan Lk	RSC	7.6	imm	M	neg	neg	3040	0	
3041	22-Apr	Okanagan Lk	RSC	7.8	imm	M	neg	neg	3041	0	
3042	22-Apr	Okanagan Lk	NSC	15.8	imm		neg	neg	3042	0	
3043	22-Apr	Okanagan Lk	NSC	29.6	imm	M	neg	neg	3043	0	
3044	22-Apr	Okanagan Lk	NSC	35.1	imm	M	neg	neg	3044	0	Ghost cells
3045	22-Apr	Okanagan Lk	NSC	41.0	imm	M	neg	neg	3045	0	
3046	22-Apr	Okanagan Lk	NSC	40.1	imm	M	neg	neg	3046	0	
3047	22-Apr	Okanagan Lk	NSC	15.4	imm		neg	neg	3047	0	
3048	22-Apr	Okanagan Lk	PCC	22.1	grav	F	neg	neg	3048	0	
3049	22-Apr	Okanagan Lk	PCC	27.1	grav	F	neg	neg	3049	0	
3050	22-Apr	Okanagan Lk	PCC	Parasite on head		?	neg	neg	3050	0	
3051	22-Apr	Okanagan Lk	NSC	10.5	imm		neg	neg	3051	0	Ghost cells
3052	22-Apr	Okanagan Lk	PCC	15.2	imm		neg	neg	3052	0	
3053	22-Apr	Okanagan Lk	PCC	18.2	imm		neg	neg	3053	0	
3054	22-Apr	Okanagan Lk	PCC	18.6	imm		neg	neg	3054	0	
3055	22-Apr	Okanagan Lk	PCC	28.0	grav	F	neg	neg	3055	0	
3056	22-Apr	Okanagan Lk	NSC	44.6	imm	M	neg	neg	3056	0	Ghost cells
3057	22-Apr	Okanagan Lk	NSC	31.6	imm	M	neg	neg	3057	0	
3058	22-Apr	Okanagan Lk	CAS	13.0	grav	F	neg	neg	3058	0	
3059	22-Apr	Okanagan Lk	CAS	10.4	post spawn	F	neg	neg	3059	0	
3060	22-Apr	Okanagan Lk	CAS	9.5	grav	M	neg	neg	3060	0	
3061	22-Apr	Okanagan Lk	CAS	12.9	grav	F	neg	neg	3061	0	
3062	22-Apr	Okanagan Lk	CAS	12.0		?	neg	neg	3062	0	
3063	22-Apr	Okanagan Lk	CAS	12.0	grav	F	neg	neg	3063	0	
3064	22-Apr	Okanagan Lk	CAS	9.4	mat	F	neg	neg	3064	0	
3065	22-Apr	Okanagan Lk	CAS	12.9	imm		neg	neg	3065	0	Ghost cells
3066	22-Apr	Okanagan Lk	PCC	10.9		?	neg	neg	3066	0	
3067	22-Apr	Okanagan Lk	CAS	9.7	grav	M	neg	neg	3067	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3068	22-Apr	Okanagan Lk	CAS	8.9	grav	F	neg	neg	3068	0	
3069	22-Apr	Okanagan Lk	CAS	9.7	grav	F	neg	neg	3069	0	
3070	22-Apr	Okanagan Lk	CAS	9.7	grav	F	neg	neg	3070	0	
3071	22-Apr	Okanagan Lk	CAS	8.7	grav	M	neg	neg	3071	0	
3072	22-Apr	Okanagan Lk	CAS	8.8	grav	M	neg	neg	3072	0	Ghost cells
3073	22-Apr	Okanagan Lk	CAS	9.1	post spawn	F	neg	neg	3073	0	
3074	22-Apr	Okanagan Lk	CAS	6.9		?	neg	neg	3074	0	
3075	22-Apr	Okanagan Lk	RSC	7.6	imm	F	neg	neg	3075	0	
3076	22-Apr	Okanagan Lk	SU	19.2		?	neg	neg	3076	0	Ghost cells
3077	22-Apr	Okanagan Lk	SU	37.5	grav	M	neg	neg	3077	0	
3078	22-Apr	Okanagan Lk	SU	41.2	grav	M	neg	neg	3078	0	immature cells
3079	22-Apr	Okanagan Lk	SU	39.4		?	neg	neg	3079	0	
3080	22-Apr	Okanagan Lk	SU	40.0	grav	M	neg	neg	3080	0	
3081	23-Apr	Skaha Lake	WF	16.2	juv		neg	neg	3081	0	Ghost cells
3082	23-Apr	Skaha Lake	WF	32.0	imm	M	neg	neg	3082	0	Ghost cells
3083	23-Apr	Skaha Lake	WF	33.5	imm	F	neg	neg	3083	0	Ghost cells
3084	23-Apr	Skaha Lake	WF	30.5	imm	F	neg	neg	3084	0	Ghost cells
3085	23-Apr	Skaha Lake	WF	29.0	imm	M	neg	neg	3085	0	Ghost cells
3086	23-Apr	Skaha Lake	WF	27.1	imm	M	neg	neg	3086	0	Ghost cells
3087	23-Apr	Skaha Lake	PCC	25.5	grav	F	neg	neg	3087	0	Ghost cells
3088	23-Apr	Skaha Lake	PCC	21.5	imm		neg	neg	3088	0	
3089	23-Apr	Skaha Lake	PMB	12.0	imm	F	neg	neg	3089	0	
3090	23-Apr	Skaha Lake	PMB	12.0	imm	F	neg	neg	3090	0	
3091	23-Apr	Skaha Lake	PMB	13.7	imm	F	neg	neg	3091	0	
3092	23-Apr	Skaha Lake	PMB	15.1	imm	F	neg	neg	3092	0	
3093	23-Apr	Skaha Lake	PMB	14.5	imm	F	neg	neg	3093	0	
3094	23-Apr	Skaha Lake	PMB	12.0	imm	M	neg	neg	3094	0	
3095	23-Apr	Skaha Lake	PMB	8.5	imm	F	neg	neg	3095	0	
3096	23-Apr	Skaha Lake	PMB	9.5	imm	F	neg	neg	3096	1	
3097	23-Apr	Skaha Lake	PMB	8.3	imm		neg	neg	3097	0	
3098	23-Apr	Skaha Lake	PMB	9.1	imm	F	neg	neg	3098	0	
3099	23-Apr	Skaha Lake	PMB	10.6	imm	F	neg	neg	3099	0	
3100	23-Apr	Skaha Lake	PMB	11.0	imm	M	neg	neg	3100	0	
3101	23-Apr	Skaha Lake	PMB	11.5	imm	M	neg	neg	3101	0	
3102	23-Apr	Skaha Lake	PMB	13.9	imm	M	neg	neg	3102	0	
3103	23-Apr	Skaha Lake	PMB	12.2	imm	M	neg	neg	3103	0	
3104	23-Apr	Skaha Lake	PMB	13.5	grav	F	neg	neg	3104	3	
3105	23-Apr	Skaha Lake	PMB	7.9	imm		neg	neg	3105	3	Ghost cells
3106	23-Apr	Skaha Lake	YP	28.5	imm	M	neg	neg	3106	0	Ghost cells
3107	23-Apr	Skaha Lake	YP	31.9	grav	F	neg	neg	3107	0	Ghost cells
3108	23-Apr	Skaha Lake	YP	23.9	grav	M	neg	neg	3108	0	
3109	23-Apr	Skaha Lake	YP	19.6	grav	F	neg	neg	3109	0	
3110	23-Apr	Skaha Lake	PCC	21.5	imm		neg	neg	3110	0	
3111	23-Apr	Skaha Lake	NSC	31.1	imm		neg	neg	3111	0	
3112	23-Apr	Skaha Lake	PCC	24.0	imm		neg	neg	3112	0	
3113	23-Apr	Skaha Lake	PCC	22.6	imm		neg	neg	3113	0	
3114	23-Apr	Skaha Lake	SMB	24.0	imm	M	neg	neg	3114	4	
3115	23-Apr	Skaha Lake	SMB	25.6	pre-spawn	M	neg	neg	3115	1	
3116	23-Apr	Skaha Lake	SMB	28.1	imm	M	neg	neg	3116	0	
3117	23-Apr	Skaha Lake	SMB	31.9	pre-spawn	F	neg	neg	3117	0	
3118	23-Apr	Skaha Lake	SMB	28.1	pre-spawn	F	neg	neg	3118	0	
3119	23-Apr	Skaha Lake	SMB	28.9	pre-spawn	F	neg	neg	3119	0	
3120	23-Apr	Skaha Lake	SMB	22.9	imm	M	neg	neg	3120	0	
3121	23-Apr	Skaha Lake	SMB	19.0	imm		neg	neg	3121	0	
3122	23-Apr	Skaha Lake	SMB	14.4	imm		neg	neg	3122	6	
3123	23-Apr	Skaha Lake	SMB	15.5	imm		neg	neg	3123	0	
3124	23-Apr	Skaha Lake	SMB	15.6	imm		neg	neg	3124	0	
3125	23-Apr	Skaha Lake	SMB	14.0	imm		neg	neg	3125	0	
3126	23-Apr	Skaha Lake	SMB	14.2	imm		neg	neg	3126	2	
3127	23-Apr	Skaha Lake	SMB	19.3	imm	M	neg	neg	3127	0	Ghost cells
3128	23-Apr	Skaha Lake	SMB	14.2	imm		neg	neg	3128	1	
3129	23-Apr	Skaha Lake	SMB	16.4	imm		neg	neg	3129	0	
3130	23-Apr	Skaha Lake	NSC	12.5	imm		neg	neg	3130	0	Ghost cells
3131	23-Apr	Skaha Lake	SMB	14.9	imm	M?	neg	neg	3131	0	
3132	23-Apr	Skaha Lake	SMB	15.1	imm	F?	neg	neg	3132	3	
3133	23-Apr	Skaha Lake	SMB	13.8	imm	M	neg	neg	3133	2	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3134	23-Apr	Skaha Lake	YP	16.3	grav	M	neg	neg	3134	0	
3135	23-Apr	Skaha Lake	SMB	9.9	imm		neg	neg	3135	0	
3136	23-Apr	Skaha Lake	PMB	7.3	imm		neg	neg	3136	5	
3137	23-Apr	Skaha Lake	SU	35.0	pre-spawn	M	neg	neg	3137	0	
3138	23-Apr	Skaha Lake	SU	37.4	imm	M	neg	neg	3138	0	
3139	23-Apr	Skaha Lake	SU	37.8	imm		neg	neg	3139	0	
3140	23-Apr	Skaha Lake	SU	36.0	imm		neg	neg	3140	900	each field has 15 to 20 inclusion body, light blue color.(confirmed by Garth)
3141	23-Apr	Skaha Lake	SU	35.1	pre-spawn	M	neg	neg	3141	2	
3142	23-Apr	Skaha Lake	SU	36.0	pre-spawn	M	neg	neg	3142	0	
3143	23-Apr	Skaha Lake	SU	36.6	pre-spawn	M	neg	neg	3143	0	
3144	23-Apr	Skaha Lake	SU	36.6	pre-spawn	M	neg	neg	3144	900	each field has 15 to 20 inclusion body, light blue color.(confirmed by Garth)
3145	23-Apr	Skaha Lake	SU	37.5	pre-spawn	F	neg	neg	3145	0	
3146	23-Apr	Skaha Lake	SU	40.0	imm		neg	neg	3146	0	
3147	23-Apr	Skaha Lake	SU	35.3	pre-spawn	M	neg	neg	3147	0	
3148	23-Apr	Skaha Lake	SU	36.0	pre-spawn	M	neg	neg	3148	0	
3149	23-Apr	Skaha Lake	SU	35.6	pre-spawn	M	neg	neg	3149	300	
3150	23-Apr	Skaha Lake	SU	37.0	pre-spawn	F	neg	neg	3150	0	
3151	23-Apr	Skaha Lake	SU	36.7	imm	M	neg	neg	3151	600	
3152	23-Apr	Skaha Lake	CAS	13.7	grav	F	neg	neg	3152	0	
3153	23-Apr	Skaha Lake	CAS	10.5	grav	F	neg	neg	3153	0	
3154	23-Apr	Skaha Lake	CAS	11.7	grav	F	neg	neg	3154	0	
3155	23-Apr	Skaha Lake	CAS	10.5	grav	F	neg	neg	3155	0	
3156	25-Apr	Osoyoos Lake	WF	17.4	imm	F	neg	neg	3156	0	
3157	25-Apr	Osoyoos Lake	WF	16.7	imm?		neg	neg	3157	0	
3158	25-Apr	Osoyoos Lake	WF	17.3	imm	M	neg	neg	3158	0	
3159	25-Apr	Osoyoos Lake	WF	17.3	imm		neg	neg	3159	0	
3160	25-Apr	Osoyoos Lake	NSC	23.2	imm		neg	neg	3160	0	
3161	25-Apr	Osoyoos Lake	WF	19.5	imm		neg	neg	3161	0	
3162	25-Apr	Osoyoos Lake	WF	16.6	imm		neg	neg	3162	0	
3163	25-Apr	Osoyoos Lake	NSC	14.5	imm		neg	neg	3163	0	
3164	25-Apr	Osoyoos Lake	NSC	18.8	imm	M	neg	neg	3164	0	
3165	25-Apr	Osoyoos Lake	WF	17.4	imm	F	neg	neg	3165	1	
3166	25-Apr	Osoyoos Lake	NSC	24.1	imm	F	neg	neg	3166	0	Ghost cells
3167	25-Apr	Osoyoos Lake	NSC	28.8	imm	F	neg	neg	3167	0	
3168	25-Apr	Osoyoos Lake	NSC	25.5	imm	M	neg	neg	3168	0	
3169	25-Apr	Osoyoos Lake	NSC	24.3	imm	F	neg	neg	3169	0	
3170	25-Apr	Osoyoos Lake	NSC	35.7	imm	M	neg	neg	3170	1	
3171	25-Apr	Osoyoos Lake	YP	15.1	spawn	M	neg	neg	3171	1	
3172	25-Apr	Osoyoos Lake	YP	18.1	grav	M	neg	neg	3172	0	
3173	25-Apr	Osoyoos Lake	YP	16.4	grav	M	neg	neg	3173	0	
3174	25-Apr	Osoyoos Lake	YP	7.9	imm		neg	neg	3174	0	
3175	25-Apr	Osoyoos Lake	YP	8.8	spawn	M	neg	neg	3175	0	
3176	25-Apr	Osoyoos Lake	YP	7.3	imm		neg	neg	3176	0	
3177	25-Apr	Osoyoos Lake	YP	7.7	grav	M	neg	neg	3177	0	
3178	25-Apr	Osoyoos Lake	YP	6.8	imm		neg	neg	3178	1	
3179	25-Apr	Osoyoos Lake	YP	15.4	grav	M	neg	neg	3179	0	
3180	25-Apr	Osoyoos Lake	YP	16.3	grav	M	neg	neg	3180	0	
3181	25-Apr	Osoyoos Lake	YP	13.6	grav	M	neg	neg	3181	0	
3182	25-Apr	Osoyoos Lake	YP	15.8	grav	M	neg	neg	3182	0	
3183	25-Apr	Osoyoos Lake	YP	13.3	grav	M	neg	neg	3183	0	
3184	25-Apr	Osoyoos Lake	YP	8.2	spawn	M	neg	neg	3184	0	
3185	25-Apr	Osoyoos Lake	YP	8.8	spawn	M	neg	neg	3185	0	
3186	25-Apr	Osoyoos Lake	YP	15.8	grav	F	neg	neg	3186	0	
3187	25-Apr	Osoyoos Lake	YP	17.8	grav	F	neg	neg	3187	0	
3188	25-Apr	Osoyoos Lake	YP	6.8	imm		neg	neg	3188	0	
3189	25-Apr	Osoyoos Lake	YP	10.3	?		neg	neg	3189	0	
3190	25-Apr	Osoyoos Lake	YP	17.3	grav	M	neg	neg	3190	0	
3191	25-Apr	Osoyoos Lake	YP	14.1	grav	M	neg	neg	3191	0	
3192	25-Apr	Osoyoos Lake	YP	14.0	grav	M	neg	neg	3192	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3193	25-Apr	Osoyoos Lake	YP	7.7	imm		neg	neg	3193	0	
3194	25-Apr	Osoyoos Lake	YP	8.5	spawn	M	neg	neg	3194	0	
3195	25-Apr	Osoyoos Lake	YP	8.1	pre-spawn	M	neg	neg	3195	0	
3196	25-Apr	Osoyoos Lake	YP	7.1	imm		neg	neg	3196	0	
3197	25-Apr	Osoyoos Lake	YP	6.9	imm		neg	neg	3197	0	
3198	25-Apr	Osoyoos Lake	YP	7.5	spawn	M	neg	neg	3198	0	
3199	25-Apr	Osoyoos Lake	YP	6.6	imm		neg	neg	3199	0	
3200	25-Apr	Osoyoos Lake	YP	7.1	?		neg	neg	3200	0	
3201	25-Apr	Osoyoos Lake	YP	9.9	grav	M	neg	neg	3201		no slide
3202	25-Apr	Osoyoos Lake	YP	6.9	?		neg	neg	3202	0	
3203	25-Apr	Osoyoos Lake	YP	6.4	?		neg	neg	3203	0	
3204	25-Apr	Osoyoos Lake	YP	7.0	spawn	M	neg	neg	3204	0	lots of WBC's, lots of ghost cells
3205	25-Apr	Osoyoos Lake	YP	6.0	imm		neg	neg	3205	0	
3206	25-Apr	Osoyoos Lake	YP	6.8	spawn	M	neg	neg	3206	0	
3207	25-Apr	Osoyoos Lake	YP	9.8	pre-spawn	M	neg	neg	3207	0	
3208	25-Apr	Osoyoos Lake	YP	9.0	imm	M	neg	neg	3208	0	
3209	25-Apr	Osoyoos Lake	YP	10.3	grav	M	neg	neg	3209	0	
3210	25-Apr	Osoyoos Lake	YP	14.0	spawn	M	neg	neg	3210	0	
3211	25-Apr	Osoyoos Lake	YP	17.3	imm	F	neg	neg	3211	0	
3212	25-Apr	Osoyoos Lake	YP	13.2	grav	M	neg	neg	3212	0	
3213	25-Apr	Osoyoos Lake	YP	13.1	grav	M	neg	neg	3213	0	
3214	25-Apr	Osoyoos Lake	YP	7.3	grav	M	neg	neg	3214	0	
3215	25-Apr	Osoyoos Lake	YP	6.8	imm		neg	neg	3215	0	
3216	25-Apr	Osoyoos Lake	YP	7.3	imm	M	neg	neg	3216	0	
3217	25-Apr	Osoyoos Lake	YP	7.4	grav	M	neg	neg	3217	0	
3218	25-Apr	Osoyoos Lake	YP	6.4	imm		neg	neg	3218	0	
3219	25-Apr	Osoyoos Lake	YP	6.2	imm		neg	neg	3219	0	
3220	25-Apr	Osoyoos Lake	YP	7.1	imm	M	neg	neg	3220	0	
3221	25-Apr	Osoyoos Lake	YP	7.4	imm		neg	neg	3221	0	
3222	25-Apr	Osoyoos Lake	YP	6.8	grav	M	neg	neg	3222	0	
3223	25-Apr	Osoyoos Lake	YP	6.8	imm		neg	neg	3223	0	
3224	25-Apr	Osoyoos Lake	YP	7.3	imm		neg	neg	3224	0	lots of ghost cells
3225	25-Apr	Osoyoos Lake	YP	6.8	imm	M	neg	neg	3225	0	
3226	25-Apr	Osoyoos Lake	YP	8.4	spawn	M	neg	neg	3226	0	
3227	25-Apr	Osoyoos Lake	YP	10.9	spawn	M	neg	neg	3227	0	
3228	25-Apr	Osoyoos Lake	YP	6.9	imm		neg	neg	3228	0	
3229	25-Apr	Osoyoos Lake	YP	7.0	spawn	M	neg	neg	3229	0	
3230	25-Apr	Osoyoos Lake	YP	8.9	spawn	M	neg	neg	3230	0	
3231	26-Apr	Osoyoos Lake	NSC	31.0	imm	M	neg	neg	3231	0	lot of lymphocytes
3232	26-Apr	Osoyoos Lake	NSC	24.8	imm	M	neg	neg	3232	0	
3233	26-Apr	Osoyoos Lake	NSC	29.5	imm	M	neg	neg	3233	24	inclusionbody very faint light blue color. Confirmed by Garth Traxler DFO
3234	26-Apr	Osoyoos Lake	NSC	27.6	imm	M	neg	neg	3234	0	
3235	26-Apr	Osoyoos Lake	CMC	28.0	imm	F	neg	neg	3235	0	
3236	26-Apr	Osoyoos Lake	SU	17.7	?		neg	neg	3236	0	high number lymphocytes
3237	26-Apr	Osoyoos Lake	NSC	24.3	imm	F	neg	neg	3237	0	
3238	26-Apr	Osoyoos Lake	NSC	32.3	imm	F	neg	neg	3238	0	
3239	26-Apr	Osoyoos Lake	CMC	30.8	grav	F	neg	neg	3239	0	
3240	26-Apr	Osoyoos Lake	NSC	24.6	imm	M	neg	neg	3240	0	
3241	26-Apr	Osoyoos Lake	CMC	24.1	imm	M	neg	neg	3241	0	
3242	26-Apr	Osoyoos Lake	NSC	40.1	imm	F	neg	neg	3242	1	
3243	26-Apr	Osoyoos Lake	SU	31.4	imm	M	neg	neg	3243	0	
3244	26-Apr	Osoyoos Lake	NSC	36.4	imm	F	neg	neg	3244	0	lot of lymphocytes
3245	26-Apr	Osoyoos Lake	SU	38.9	mature	M	neg	neg	3245	0	high number lymphocytes
3246	26-Apr	Osoyoos Lake	NSC	42.8	imm	F	neg	neg	3246	0	
3247	26-Apr	Osoyoos Lake	NSC	43.8	imm	F	neg	neg	3247	51	confirmed by garth
3248	26-Apr	Osoyoos Lake	SU	43.4	mature	M	neg	neg	3248	0	
3249	26-Apr	Osoyoos Lake	SU	43.1	mature	M	neg	neg	3249	0	
3250	26-Apr	Osoyoos Lake	SU	45.5	grav	F	neg	neg	3250	0	
3251	26-Apr	Osoyoos Lake	SU	14.1	?		neg	neg	3251	0	high number lymphocytes
3252	26-Apr	Osoyoos Lake	YP	13.8	grav	M	neg	neg	3252	0	
3253	26-Apr	Osoyoos Lake	YP	16.4	grav	M	neg	neg	3253	0	
3254	26-Apr	Osoyoos Lake	YP	13.3	grav	M	neg	neg	3254	0	
3255	26-Apr	Osoyoos Lake	YP	15.2	grav	M	neg	neg	3255	0	
3256	26-Apr	Osoyoos Lake	YP	13.3	grav	F	neg	neg	3256	0	
3257	26-Apr	Osoyoos Lake	YP	14.8	grav	M	neg	neg	3257	0	
3258	26-Apr	Osoyoos Lake	YP	15.4	grav	M	neg	neg	3258	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3259	26-Apr	Osoyoos Lake	YP	14.2	grav	M	neg	neg	3259	?	unreadable-too thick
3260	26-Apr	Osoyoos Lake	YP	15.8	grav	M	neg	neg	3260	0	
3261	26-Apr	Osoyoos Lake	YP	15.5	grav	M	neg	neg	3261	0	
3262	26-Apr	Osoyoos Lake	YP	16.1	grav	M	neg	neg	3262	0	
3263	26-Apr	Osoyoos Lake	YP	15.7	grav	M	neg	neg	3263	0	
3264	26-Apr	Osoyoos Lake	YP	16.8	grav	M	neg	neg	3264	0	
3265	26-Apr	Osoyoos Lake	YP	14.6	grav	M	neg	neg	3265	1	
3266	26-Apr	Osoyoos Lake	YP	15.2	grav	M	neg	neg	3266	?	unreadable-too thick
3267	26-Apr	Osoyoos Lake	YP	15.1	grav	M	neg	neg	3267	0	
3268	26-Apr	Osoyoos Lake	YP	15.0	grav	M	neg	neg	3268	0	
3269	26-Apr	Osoyoos Lake	YP	15.3	grav	M	neg	neg	3269	1	
3270	26-Apr	Osoyoos Lake	YP	13.9	grav	M	neg	neg	3270	0	hore-shoe shaped nuclei present. Higher number of lymphocytes present
3271	26-Apr	Osoyoos Lake	YP	14.9	grav	M	neg	neg	3271	0	
3272	26-Apr	Osoyoos Lake	YP	19.4	grav	F	neg	neg	3272	0	
3273	26-Apr	Osoyoos Lake	YP	16.9	grav	M	neg	neg	3273	?	unreadable-too thick
3274	26-Apr	Osoyoos Lake	YP	14.8	grav	M	neg	neg	3274	0	
3275	26-Apr	Osoyoos Lake	YP	15.4	grav	M	neg	neg	3275	0	
3276	26-Apr	Osoyoos Lake	YP	16.2	grav	M	neg	neg	3276	0	
3277	26-Apr	Osoyoos Lake	YP	15.4	grav	M	neg	neg	3277	0	only 50 good fields of view blood cells, other parts were too crowded
3278	26-Apr	Osoyoos Lake	YP	15.6	grav	M	neg	neg	3278	0	
3279	26-Apr	Osoyoos Lake	YP	15.1	grav	M	neg	neg	3279	0	
3280	26-Apr	Osoyoos Lake	YP	14.9	grav	M	neg	neg	3280	0	
3281	26-Apr	Osoyoos Lake	YP	12.6	grav	M	neg	neg	3281	0	
3282	3-Jun	Okanogan Lk	RSC	7.0		F	neg	neg	3282	0	
3283	3-Jun	Okanogan Lk	RSC	7.0		F	neg	neg	3283	0	
3284	3-Jun	Okanogan Lk	RSC	6.6		F	neg	neg	3284	0	immature cells
3285	3-Jun	Okanogan Lk	RSC	8.6		M	neg	neg	3285	0	
3286	3-Jun	Okanogan Lk	RSC	9.1		F	neg	neg	3286	0	
3287	3-Jun	Okanogan Lk	RSC	NO			neg	neg	3287		NO SAMPLE
3288	3-Jun	Okanogan Lk	RSC	10.4		F	neg	neg	3288	0	
3289	3-Jun	Okanogan Lk	RSC	6.4	juv	M?	neg	neg	3289	0	
3290	3-Jun	Okanogan Lk	RSC	6.9	juv	M?	neg	neg	3290	0	immature cells
3291	3-Jun	Okanogan Lk	RSC	7.0	juv	M?	neg	neg	3291	0	immature cells
3292	3-Jun	Okanogan Lk	RSC	7.6	juv	M?	neg	neg	3292	0	immature cells
3293	3-Jun	Okanogan Lk	RSC	5.5	juv	M?	neg	neg	3293	0	immature cells
3294	3-Jun	Okanogan Lk	RSC	6.8	juv	M?	neg	neg	3294	0	
3295	3-Jun	Okanogan Lk	RSC	8.5		F	neg	neg	3295	0	
3296	3-Jun	Okanogan Lk	CAS	9.1	spawn	F	neg	neg	3296	0	
3297	3-Jun	Okanogan Lk	CAS	14.1	imm	F	neg	neg	3297	0	
3298	3-Jun	Okanogan Lk	CAS	11.2	imm	M	neg	neg	3298	0	
3299	3-Jun	Okanogan Lk	WF	15.4	imm		neg	neg	3299	0	
3300	3-Jun	Okanogan Lk	WF	23.4	imm		neg	neg	3300	0	
3301	3-Jun	Okanogan Lk	WF	18.1	imm		neg	neg	3301	0	
3302	3-Jun	Okanogan Lk	WF	15.2	juv		neg	neg	3302	0	
3303	3-Jun	Okanogan Lk	WF	16.4	juv		neg	neg	3303	0	
3304	3-Jun	Okanogan Lk	WF	16.0	juv		neg	neg	3304	0	
3305	3-Jun	Okanogan Lk	WF	29.4		?	neg	neg	3305	0	
3306	3-Jun	Okanogan Lk	PCC	18.4		?	neg	neg	3306	0	
3307	3-Jun	Okanogan Lk	PCC	19.3	juv		neg	neg	3307	0	
3308	3-Jun	Okanogan Lk	PCC	21.0	juv		neg	neg	3308	0	
3309	3-Jun	Okanogan Lk	PCC	14.4	juv		neg	neg	3309	0	
3310	3-Jun	Okanogan Lk	PCC	14.9	juv	juv	neg	neg	3310	0	
3311	3-Jun	Okanogan Lk	PCC	15.9	juv	F	neg	neg	3311	0	
3312	3-Jun	Okanogan Lk	PCC	21.4	imm	M	neg	neg	3312	0	
3313	3-Jun	Okanogan Lk	PCC	22.6		F	neg	neg	3313	0	
3314	3-Jun	Okanogan Lk	PCC	26.0	imm	F	neg	neg	3314	0	
3315	3-Jun	Okanogan Lk	PCC	19.3	imm	M	neg	neg	3315	0	
3316	3-Jun	Okanogan Lk	PCC	22.9	imm	F	neg	neg	3316	0	
3317	3-Jun	Okanogan Lk	PCC	18.8	?	?	neg	neg	3317	0	
3318	3-Jun	Okanogan Lk	PCC	16.6	?	?	neg	neg	3318	0	
3319	3-Jun	Okanogan Lk	PCC	18.9	juv		neg	neg	3319	0	immature cells
3320	3-Jun	Okanogan Lk	PCC	19.4	juv		neg	neg	3320	0	
3321	3-Jun	Okanogan Lk	NSC	10.5	?	?	neg	neg	3321	0	
3322	3-Jun	Okanogan Lk	CMC	14.4	?	?	neg	neg	3322	0	
3323	3-Jun	Okanogan Lk	PCC	10.1	juv		neg	neg	3323	0	
3324	3-Jun	Okanogan Lk	PCC	20.8		M	neg	neg	3324	0	
3325	3-Jun	Okanogan Lk	PCC	14.4	juv		neg	neg	3325	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3326	3-Jun	Okanogan Lk	PCC	11.0	juv		neg	neg	3326	0	
3327	3-Jun	Okanogan Lk	NSC	15.8	juv		neg	neg	3327	0	immature cells and ghost cells
3328	3-Jun	Okanogan Lk	NSC	20.4	juv		neg	neg	3328	0	
3329	3-Jun	Okanogan Lk	NSC	32.5		M?	neg	neg	3329	0	immature and ghost cells
3330	3-Jun	Okanogan Lk	NSC	32.0		M?	neg	neg	3330	0	
3331	3-Jun	Okanogan Lk	NSC	25.5		M?	neg	neg	3331	0	
3332	3-Jun	Okanogan Lk	NSC	31.5		M?	neg	neg	3332	0	
3333	3-Jun	Okanogan Lk	NSC	10.5	juv		neg	neg	3333	0	
3334	3-Jun	Okanogan Lk	PCC	10.8	juv		neg	neg	3334	0	
3335	3-Jun	Okanogan Lk	NSC	14.8	juv		neg	neg	3335	0	immature cells
3336	3-Jun	Okanogan Lk	PCC	11.1	juv		neg	neg	3336	0	
3337	3-Jun	Okanogan Lk	NSC	16.7	juv		neg	neg	3337	0	
3338	3-Jun	Okanogan Lk	CAS	17.6		M	neg	neg	3338	0	
3339	3-Jun	Okanogan Lk	SU	29.0	juv	M	neg	neg	3339	0	immature cells
3340	3-Jun	Okanogan Lk	SU	34.5	juv		neg	neg	3340		no slide
3341	3-Jun	Okanogan Lk	SU	41.0	spawn	M	neg	neg	3341	0	
3342	3-Jun	Okanogan Lk	SU	36.5		M	neg	neg	3342	0	
3343	3-Jun	Okanogan Lk	SU	21.4	juv		neg	neg	3343	0	immature cells
3344	3-Jun	Okanogan Lk	SU	21.4	juv		neg	neg	3344	0	
3345	3-Jun	Okanogan Lk	SU	21.9	juv		neg	neg	3345	0	
3346	3-Jun	Okanogan Lk	SU	26.0	juv		neg	neg	3346	0	lymphocyte cells
3347	3-Jun	Okanogan Lk	SU	22.2	juv		neg	neg	3347	0	
3348	3-Jun	Okanogan Lk	SU	20.1	juv		neg	neg	3348	0	lymphocyte cells
3349	3-Jun	Okanogan Lk	SU	23.4	juv		neg	neg	3349	0	immature cells and ghost cells
3350	3-Jun	Okanogan Lk	SU	24.0	juv	M	neg	neg	3350	0	
3351	3-Jun	Okanogan Lk	SU	23.7	juv		neg	neg	3351	0	immature cells
3352	3-Jun	Okanogan Lk	SU	22.3	juv		neg	neg	3352	0	lymphocyte cells
3353	3-Jun	Okanogan Lk	SU	31.5		M	neg	neg	3353	0	
3354	3-Jun	Okanogan Lk	SU	32.5		M	neg	neg	3354	0	
3355	3-Jun	Okanogan Lk	SU	40.0		M	neg	neg	3355	0	
3356	3-Jun	Okanogan Lk	SU	37.5		F?	neg	neg	3356	0	
3357	3-Jun	Okanogan Lk	SU	40.0	pre-spawn	M	neg	neg	3357	0	
3358	5-Jun	Skaha Lake	NSC	21.7	juv		neg	neg	3358	0	
3359	5-Jun	Skaha Lake	NSC	22.4	juv		neg	neg	3359	0	
3360	5-Jun	Skaha Lake	NSC	22.4	juv		neg	neg	3360	0	
3361	5-Jun	Skaha Lake	NSC	19.0	juv		neg	neg	3361	0	
3362	5-Jun	Skaha Lake	NSC	15.5	juv		neg	neg	3362	0	
3363	5-Jun	Skaha Lake	PCC	14.2	imm		neg	neg	3363	0	
3364	5-Jun	Skaha Lake	PCC	7.1	imm		neg	neg	3364	0	
3365	5-Jun	Skaha Lake	PCC	12.1	imm		neg	neg	3365	0	
3366	5-Jun	Skaha Lake	PCC	14.1	imm		neg	neg	3366	0	Ghost cells
3367	5-Jun	Skaha Lake	NSC	18.1	juv		neg	neg	3367	0	
3368	5-Jun	Skaha Lake	NSC	18.4	juv		neg	neg	3368	0	
3369	5-Jun	Skaha Lake	PCC	14.1	imm		neg	neg	3369	0	
3370	5-Jun	Skaha Lake	PCC	7.7	imm		neg	neg	3370		no slide
3371	5-Jun	Skaha Lake	CAS	6.5	imm		neg	neg	3371	2	immature cells
3372	5-Jun	Skaha Lake	CAS	9.6	imm		neg	neg	3372	0	
3373	5-Jun	Skaha Lake	NSC	17.2	juv		neg	neg	3373	0	
3374	5-Jun	Skaha Lake	SU	36.1		F	neg	neg	3374	1	
3375	5-Jun	Skaha Lake	SU	30.2		F	neg	neg	3375	0	
3376	5-Jun	Skaha Lake	SU	30.0		M	neg	neg	3376	0	
3377	5-Jun	Skaha Lake	CAS	5.2	imm		neg	neg	3377	0	
3378	5-Jun	Skaha Lake	CAS	5.1	imm		neg	neg	3378		no slide
3379	5-Jun	Skaha Lake	SU	18.2		M	neg	neg	3379		no slide
3380	5-Jun	Skaha Lake	SU	15.2		F	neg	neg	3380	0	
3381	5-Jun	Skaha Lake	SU	11.0		M	neg	neg	3381	0	
3382	5-Jun	Skaha Lake	SU	35.1		F	neg	neg	3382	0	
3383	5-Jun	Skaha Lake	SU	37.7		M	neg	neg	3383	0	immature cells
3384	5-Jun	Skaha Lake	CAS	5.6	imm		neg	neg	3384	0	
3385	5-Jun	Skaha Lake	NSC	29.7	imm		neg	neg	3385	0	immature cells
3386	5-Jun	Skaha Lake	SU	37.1		M	neg	neg	3386	0	
3387	5-Jun	Skaha Lake	SU	34.9		F	neg	neg	3387	0	
3388	5-Jun	Skaha Lake	SU	35.5	pre-spawn	M	neg	neg	3388	0	
3389	5-Jun	Skaha Lake	SU	38.0	?	?	neg	neg	3389	0	
3390	5-Jun	Skaha Lake	SU	36.0		M	neg	neg	3390	0	
3391	5-Jun	Skaha Lake	SU	38.5		M	neg	neg	3391	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3392	5-Jun	Skaha Lake	SU	38.7		F	neg	neg	3392	0	
3393	5-Jun	Skaha Lake	SU	39.7		M	neg	neg	3393	0	
3394	5-Jun	Skaha Lake	SU	36.5	pre-spawn	M	neg	neg	3394	0	
3395	5-Jun	Skaha Lake	SMB	18.4	imm		neg	neg	3395	2	
3396	5-Jun	Skaha Lake	SMB	15.1	imm		neg	neg	3396	0	
3397	5-Jun	Skaha Lake	SMB	20.0	imm		neg	neg	3397	12	big inclusion body; blue light color, the other side has a lot of artifacts
3398	5-Jun	Skaha Lake	SMB	20.2	imm		neg	neg	3398	40	some are big inclusion body, some are small inclusion body
3399	5-Jun	Skaha Lake	SMB	22.0	imm	M	neg	neg	3399	0	immature cells
3400	5-Jun	Skaha Lake	SMB	24.3	imm	M	neg	neg	3400	0	
3401	5-Jun	Skaha Lake	SMB	31.9	imm	M	neg	neg	3401	3	
3402	5-Jun	Skaha Lake	SMB	23.5	imm	M	neg	neg	3402	20	blue light color
3403	5-Jun	Skaha Lake	SMB	15.0	imm		neg	neg	3403	40	4 inclusion bodies in one cell
3404	5-Jun	Skaha Lake	SMB	13.9	imm		neg	neg	3404	0	
3405	5-Jun	Skaha Lake	SMB	18.3	imm		neg	neg	3405	60	there are a lot of artifacts like inclusion body's shape outside of cells
3406	5-Jun	Skaha Lake	SMB	22.9	imm	F	neg	neg	3406	2	
3407	5-Jun	Skaha Lake	SMB	15.4	imm		neg	neg	3407	0	
3408	5-Jun	Skaha Lake	SMB	21.6	imm	F	neg	neg	3408	0	
3409	5-Jun	Skaha Lake	SMB	20.0	imm	M	neg	neg	3409	10	light blue color, near nuclei
3410	5-Jun	Skaha Lake	SMB	22.5	imm	M	neg	neg	3410	0	
3411	5-Jun	Skaha Lake	SMB	32.6	spawn	F	neg	neg	3411	1	
3412	5-Jun	Skaha Lake	SMB	26.3	imm	M	neg	neg	3412	5	there are a lot of artifacts like inclusion body's shape outside of cells
3413	5-Jun	Skaha Lake	SMB	21.0	imm		neg	neg	3413	0	there are a lot of artifact like inclusion body's shape outside of cells
3414	5-Jun	Skaha Lake	SMB	14.6	imm		neg	neg	3414	20	there are a lot of artifacts
3415	5-Jun	Skaha Lake	SMB	14.7	imm		neg	neg	3415	0	
3416	5-Jun	Skaha Lake	SMB	14.8	imm		neg	neg	3416	0	
3417	5-Jun	Skaha Lake	SMB	18.5	imm		neg	neg	3417	2	ghost cells
3418	5-Jun	Skaha Lake	SMB	23.4	imm	M	neg	neg	3418	0	
3419	5-Jun	Skaha Lake	SMB	21.2	imm		neg	neg	3419	0	
3420	5-Jun	Skaha Lake	SMB	23.3	imm	M	neg	neg	3420	0	immature cells
3421	5-Jun	Skaha Lake	SMB	21.9	imm		neg	neg	3421	0	
3422	5-Jun	Skaha Lake	SMB	28.7	imm	M	neg	neg	3422	0	
3423	5-Jun	Skaha Lake	SMB	26.0	imm	M	neg	neg	3423	0	
3424	5-Jun	Skaha Lake	SMB	25.5	spawn	F	neg	neg	3424	3	
3425	5-Jun	Skaha Lake	SMB	20.1	imm	M	neg	neg	3425	0	immature cells
3426	5-Jun	Skaha Lake	SMB	33.2	imm		neg	neg	3426	0	
3427	5-Jun	Skaha Lake	SMB	13.9	imm	M	neg	neg	3427	0	
3428	5-Jun	Skaha Lake	SMB	14.1	imm		neg	neg	3428	0	
3429	5-Jun	Skaha Lake	SMB	15.2	imm		neg	neg	3429	0	
3430	5-Jun	Skaha Lake	SMB	15.6	imm		neg	neg	3430	0	
3431	5-Jun	Skaha Lake	SMB	13.6	imm		neg	neg	3431	0	
3432	5-Jun	Skaha Lake	SMB	14.5	imm	M	neg	neg	3432	0	
3433	6-Jun	Osoyoos	SU	45.0	?	?	neg	neg	3433	0	Ghost cells
3434	6-Jun	Osoyoos	NSC	31.5	imm	F	neg	neg	3434	0	
3435	6-Jun	Osoyoos	SU	34.5	imm	F	neg	neg	3435	0	
3436	6-Jun	Osoyoos	SU	43.0	imm	F	neg	neg	3436	0	
3437	6-Jun	Osoyoos	SU	46.5	spawn	F	neg	neg	3437	0	immature cells
3438	6-Jun	Osoyoos	SU	38.0	?	?	neg	neg	3438	0	ghost cells
3439	6-Jun	Osoyoos	SU	45.0	spawn	M	neg	neg	3439	0	
3440	6-Jun	Osoyoos	SU	39.5	imm	F	neg	neg	3440	0	ghost cells
3441	6-Jun	Osoyoos	SU	50.5	imm	F	neg	neg	3441	0	
3442	6-Jun	Osoyoos	SU	47.5	imm	F	neg	neg	3442	0	
3443	6-Jun	Osoyoos	SU	9.5	juv		neg	neg	3443	0	ghost cells and immature cells
3444	6-Jun	Osoyoos	SU	47.0	imm	F	neg	neg	3444	3	
3445	6-Jun	Osoyoos	SU	44.0	pre-spawn	M	neg	neg	3445	0	
3446	6-Jun	Osoyoos	SU	47.0	imm	F	neg	neg	3446	3	
3447	6-Jun	Osoyoos	SU	15.7	imm		neg	neg	3447	0	
3448	6-Jun	Osoyoos	SU	16.0	juv	M	neg	neg	3448	0	
3449	6-Jun	Osoyoos	SU	13.1	imm		neg	neg	3449	0	
3450	6-Jun	Osoyoos	SU	13.0	juv		neg	neg	3450	0	immature cells
3451	6-Jun	Osoyoos	SU	16.1	juv		neg	neg	3451	0	
3452	6-Jun	Osoyoos	SU	16.0	imm		neg	neg	3452	1	immature cells
3453	6-Jun	Osoyoos	SU	16.4	juv		neg	neg	3453	2	ghost cells

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3454	6-Jun	Osoyoos	WF	21.9	juv		neg	neg	3454	0	
3455	6-Jun	Osoyoos	WF	20.0	juv		neg	neg	3455	3	
3456	6-Jun	Osoyoos	WF	22.3	juv		neg	neg	3456	0	
3457	6-Jun	Osoyoos	NSC	20.6	juv		neg	neg	3457	0	
3458	6-Jun	Osoyoos	NSC	30.3	imm	F	neg	neg	3458	0	
3459	6-Jun	Osoyoos	SMB	25.5	juv		neg	neg	3459	0	
3460	6-Jun	Osoyoos	SMB	25.5	juv		neg	neg	3460	0	
3461	6-Jun	Osoyoos	SMB	23.0	juv		neg	neg	3461	0	
3462	6-Jun	Osoyoos	SMB	31.5		F	neg	neg	3462	10	inclusions near nuclei
3463	6-Jun	Osoyoos	SMB	37.0		F	neg	neg	3463	0	
3464	6-Jun	Osoyoos	YP	13.0	juv		neg	neg	3464	0	ghost cells
3465	6-Jun	Osoyoos	YP	14.0	imm	F	neg	neg	3465	0	
3466	6-Jun	Osoyoos	SU	12.8	juv		neg	neg	3466	0	
3467	6-Jun	Osoyoos	YP	13.0	imm	F	neg	neg	3467	0	
3468	6-Jun	Osoyoos	YP	15.1	imm	M	neg	neg	3468	0	
3469	6-Jun	Osoyoos	YP	13.2	juv		neg	neg	3469	0	
3470	6-Jun	Osoyoos	YP	13.4	imm	F	neg	neg	3470	0	
3471	6-Jun	Osoyoos	YP	13.9	imm	F	neg	neg	3471	0	
3472	6-Jun	Osoyoos	YP	13.0	imm	M	neg	neg	3472	0	
3473	6-Jun	Osoyoos	YP	13.9	imm	M	neg	neg	3473	0	ghost cells
3474	6-Jun	Osoyoos	YP	13.5	imm	M	neg	neg	3474	0	
3475	7-Jun	Osoyoos	SU	49.5	pre-spawn	F	neg	neg	3475	0	
3476	7-Jun	Osoyoos	SU	43.0	pre-spawn	F	neg	neg	3476	1	ghost cells
3477	7-Jun	Osoyoos	SU	40.5	pre-spawn	M	neg	neg	3477	0	
3478	7-Jun	Osoyoos	SU	44.5	pre-spawn	F	neg	neg	3478	0	
3479	7-Jun	Osoyoos	SU	25.4	juv		neg	neg	3479	0	
3480	7-Jun	Osoyoos	SU	48.0		M	neg	neg	3480	0	immature cells and ghost cells
3481	7-Jun	Osoyoos	SU	37.5	spawn	M	neg	neg	3481	20	2 cells have two inclusion body
3482	7-Jun	Osoyoos	SU	43.0		F	neg	neg	3482	0	
3483	7-Jun	Osoyoos	SU	45.0		F	neg	neg	3483	0	
3484	7-Jun	Osoyoos	SU	43.0		F	neg	neg	3484	0	
3485	7-Jun	Osoyoos	SU	45.5		F	neg	neg	3485	0	
3486	7-Jun	Osoyoos	SU	42.0	imm	M	neg	neg	3486	0	
3487	7-Jun	Osoyoos	SU	40.5	imm	M	neg	neg	3487	0	
3488	7-Jun	Osoyoos	SU	38.5	spawn er	M	neg	neg	3488	0	
3489	7-Jun	Osoyoos	SU	44.0		M	neg	neg	3489	0	
3490	7-Jun	Osoyoos	SU	19.6	juv		neg	neg	3490	0	
3491	7-Jun	Osoyoos	SU	15.4	juv		neg	neg	3491	3	immature cells and ghost cells
3492	7-Jun	Osoyoos	NSC	35.0	imm		neg	neg	3492	0	immature cells
3493	7-Jun	Osoyoos	NSC	12.0	imm		neg	neg	3493	0	
3494	7-Jun	Osoyoos	NSC	12.4	imm		neg	neg	3494	0	
3495	7-Jun	Osoyoos	NSC	13.0	imm		neg	neg	3495	2	immature cells
3496	7-Jun	Osoyoos	NSC	10.8	imm		neg	neg	3496	0	immature cells
3497	7-Jun	Osoyoos	BCB	9.4	imm	M	neg	neg	3497	9	2 cells have pink color inclusion body, 7 cells have light blue color incision body
3498	7-Jun	Osoyoos	BCB	10.8	imm	F	neg	neg	3498	1	pink pale color
3499	7-Jun	Osoyoos	BCB	23.5	imm	M	neg	neg	3499	0	
3500	7-Jun	Osoyoos	BCB	25.5		M	neg	neg	3500	0	
3501	7-Jun	Osoyoos	BCB	26.5		F	neg	neg	3501	0	
3502	7-Jun	Osoyoos	BCB	29.5		M	neg	neg	3502	2	1 blue color, 1 pink color inclusion body
3503	7-Jun	Osoyoos	SMB	27.0	juv		neg	neg	3503	5	blue light color
3504	7-Jun	Osoyoos	SMB	23.1	imm		neg	neg	3504	4	blue light color
3505	7-Jun	Osoyoos	SMB	23.2	imm	F	neg	neg	3505	2	blue light color
3506	7-Jun	Osoyoos	SMB	19.6	imm		neg	neg	3506	3	blue light color
3507	7-Jun	Osoyoos	SMB	20.6	juv		neg	neg	3507	3	blue light color
3508	7-Jun	Osoyoos	SMB	21.0	juv		neg	neg	3508	0	
3509	7-Jun	Osoyoos	SMB	20.3	imm		neg	neg	3509	0	
3510	7-Jun	Osoyoos	SMB	22.3	imm		neg	neg	3510	0	
3511	7-Jun	Osoyoos	SMB	24.0	imm		neg	neg	3511	1	
3512	7-Jun	Osoyoos	SMB	35.0	imm	F	neg	neg	3512	0	ghost cells
3513	7-Jun	Osoyoos	SMB	42.5	imm	F	neg	neg	3513	0	
3514	7-Jun	Osoyoos	SMB	34.0		F	neg	neg	3514	2	
3515	7-Jun	Osoyoos	SMB	34.5		F	neg	neg	3515	1	
3516	7-Jun	Osoyoos	SMB	32.5	imm	F	neg	neg	3516	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
3517	7-Jun	Osoyoos	SMB	41.5		F	neg	neg	3517	0	
3518	7-Jun	Osoyoos	YP	16.2	imm		neg	neg	3518	0	
3519	7-Jun	Osoyoos	YP	12.8	imm	F	neg	neg	3519	0	
3520	7-Jun	Osoyoos	YP	17.6	imm	F	neg	neg	3520	0	
3521	7-Jun	Osoyoos	YP	16.2	imm		neg	neg	3521	0	
3522	7-Jun	Osoyoos	YP	15.4	imm		neg	neg	3522	0	
3523	7-Jun	Osoyoos	YP	13.2	imm		neg	neg	3523	0	
3524	7-Jun	Osoyoos	YP	14.8	imm	M	neg	neg	3524	0	
3525	7-Jun	Osoyoos	YP	18.1	imm		neg	neg	3525	0	immature cells and ghost cells
3526	7-Jun	Osoyoos	YP	11.1	imm		neg	neg	3526	0	immature cells
3527	7-Jun	Osoyoos	YP	16.6	imm		neg	neg	3527	0	immature cells
4001	21-Aug	Okanagan Lk	WF	9.3	imm		neg	neg	4001	0	
4002	21-Aug	Okanagan Lk	WF	10.1	imm		neg	neg	4002	0	
4003	21-Aug	Okanagan Lk	WF	10.4	imm		neg	neg	4003	0	
4004	21-Aug	Okanagan Lk	WF	9.3	imm		neg	neg	4004	0	
4005	21-Aug	Okanagan Lk	WF	9.1	imm		neg	neg	4005	0	
4006	21-Aug	Okanagan Lk	WF	9.7	imm		neg	neg	4006	0	
4007	21-Aug	Okanagan Lk	WF	19.7	imm		neg	neg	4007	0	
4008	21-Aug	Okanagan Lk	WF	18.9	imm		neg	neg	4008	0	
4009	21-Aug	Okanagan Lk	WF	8.7	imm		neg	neg	4009	0	
4010	21-Aug	Okanagan Lk	WF	9.4	imm		neg	neg	4010	0	
4011	21-Aug	Okanagan Lk	WF	9.2	imm		neg	neg	4011	0	
4012	21-Aug	Okanagan Lk	WF	8.7	imm		neg	neg	4012	0	
4013	21-Aug	Okanagan Lk	WF	9.7	imm		neg	neg	4013	0	
4014	21-Aug	Okanagan Lk	WF	10.0	imm		neg	neg	4014	0	
4015	21-Aug	Okanagan Lk	WF	10.2	imm		neg	neg	4015	0	
4016	21-Aug	Okanagan Lk	WF	10.0	imm		neg	neg	4016	0	
4017	21-Aug	Okanagan Lk	WF	10.7	imm		neg	neg	4017	0	
4018	21-Aug	Okanagan Lk	PCC	10.1	imm		neg	neg	4018	0	
4019	21-Aug	Okanagan Lk	PCC	10.0	imm		neg	neg	4019	0	
4020	21-Aug	Okanagan Lk	PCC	12.9	imm		neg	neg	4020	0	
4021	21-Aug	Okanagan Lk	PCC	13.0	imm		neg	neg	4021	0	
4022	21-Aug	Okanagan Lk	PCC	16.8	imm		neg	neg	4022	0	
4023	21-Aug	Okanagan Lk	PCC	16.4	imm		neg	neg	4023	0	
4024	21-Aug	Okanagan Lk	PCC	21.9	imm	F	neg	neg	4024	0	
4025	21-Aug	Okanagan Lk	PCC	21.5	imm	F	neg	neg	4025	0	
4026	21-Aug	Okanagan Lk	PCC	22.1	imm	F	neg	neg	4026	0	
4027	21-Aug	Okanagan Lk	PCC	9.2	imm		neg	neg	4027	0	
4028	21-Aug	Okanagan Lk	PCC	14.0	imm		neg	neg	4028	0	
4029	21-Aug	Okanagan Lk	PCC	13.5	imm		neg	neg	4029	0	
4030	21-Aug	Okanagan Lk	PCC	14.1	imm		neg	neg	4030	0	
4031	21-Aug	Okanagan Lk	PCC	13.1	imm		neg	neg	4031	0	
4032	21-Aug	Okanagan Lk	PCC	17.1	imm		neg	neg	4032	0	
4033	21-Aug	Okanagan Lk	RSC	6.1	imm		neg	neg	4033	0	
4034	21-Aug	Okanagan Lk	RSC	5.3	imm		neg	neg	4034	0	
4035	21-Aug	Okanagan Lk	RSC	5.6	imm		neg	neg	4035	0	
4036	21-Aug	Okanagan Lk	RSC	6.2	imm		neg	neg	4036	0	
4037	21-Aug	Okanagan Lk	RSC	7.1	imm		neg	neg	4037	0	
4038	21-Aug	Okanagan Lk	RSC	5.2	imm		neg	neg	4038	0	
4039	21-Aug	Okanagan Lk	RSC	8.2	imm		neg	neg	4039	0	
4040	21-Aug	Okanagan Lk	RSC	6.0	imm		neg	neg	4040	0	
4041	21-Aug	Okanagan Lk	RSC	7.0	imm		neg	neg	4041	0	
4042	21-Aug	Okanagan Lk	RSC	9.0	imm		neg	neg	4042	0	
4043	21-Aug	Okanagan Lk	RSC	7.9	imm	F	neg	neg	4043	0	
4044	21-Aug	Okanagan Lk	RSC	6.0	imm		neg	neg	4044	0	
4045	21-Aug	Okanagan Lk	RSC	7.8	imm		neg	neg	4045	0	
4046	21-Aug	Okanagan Lk	RSC	9.5	imm	F	neg	neg	4046	0	
4047	21-Aug	Okanagan Lk	RSC	6.2	imm		neg	neg	4047	0	
4048	21-Aug	Okanagan Lk	NSC	5.3	imm		neg	neg	4048	0	
4049	21-Aug	Okanagan Lk	NSC	42.5	imm		neg	neg	4049	0	
4050	21-Aug	Okanagan Lk	NSC	39.5	imm	F	neg	neg	4050	0	
4051	21-Aug	Okanagan Lk	NSC	37.3	imm		neg	neg	4051	0	
4052	21-Aug	Okanagan Lk	NSC	34.4	imm		neg	neg	4052	0	
4053	21-Aug	Okanagan Lk	NSC	37.6	imm		neg	neg	4053	0	
4054	21-Aug	Okanagan Lk	NSC	7.6	imm		neg	neg	4054	0	
4055	21-Aug	Okanagan Lk	NSC	6.7	imm		neg	neg	4055	0	
4056	21-Aug	Okanagan Lk	NSC	7.9	imm		neg	neg	4056	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4057	21-Aug	Okanagan Lk	NSC	6.8	imm		neg	neg	4057	0	
4058	21-Aug	Okanagan Lk	NSC	6.8	imm		neg	neg	4058	0	
4059	21-Aug	Okanagan Lk	NSC	8.7	imm		neg	neg	4059	0	
4060	21-Aug	Okanagan Lk	NSC	9.3	imm		neg	neg	4060	0	
4061	21-Aug	Okanagan Lk	SU	29.6	imm		neg	neg	4061	0	
4062	21-Aug	Okanagan Lk	SU	23.9	imm		neg	neg	4062	0	
4063	21-Aug	Okanagan Lk	SU	23.2	imm		neg	neg	4063	0	
4064	21-Aug	Okanagan Lk	SU	33.7	imm		neg	neg	4064	0	
4065	21-Aug	Okanagan Lk	SU	36.5	imm	M	neg	neg	4065	0	
4066	21-Aug	Okanagan Lk	SU	40.1	imm	F	neg	neg	4066	0	
4067	21-Aug	Okanagan Lk	NSC	6.9	imm		neg	neg	4067	0	
4068	21-Aug	Okanagan Lk	NSC	9.6	imm		neg	neg	4068	0	
4069	21-Aug	Okanagan Lk	SU	10.4	imm		neg	neg	4069	0	
4070	21-Aug	Okanagan Lk	SU	10.3	imm		neg	neg	4070	0	
4071	21-Aug	Okanagan Lk	SU	15.6	imm		neg	neg	4071	0	
4072	21-Aug	Okanagan Lk	SU	16.5	imm		neg	neg	4072	0	
4073	21-Aug	Okanagan Lk	CAS	12.6	imm		neg	neg	4073	0	
4074	21-Aug	Okanagan Lk	CAS	10.9	imm		neg	neg	4074	0	
4075	21-Aug	Okanagan Lk	CAS	14.4	imm		neg	neg	4075	0	
4076	22-Aug	Skaha Lake	PMB	3.6	imm		neg	neg	4076	0	
4077	22-Aug	Skaha Lake	PMB	4.5	imm		neg	neg	4077	0	
4078	22-Aug	Skaha Lake	PMB	7.2	imm		neg	neg	4078	0	
4079	22-Aug	Skaha Lake	NSC	9.1	imm		neg	neg	4079	0	
4080	22-Aug	Skaha Lake	NSC	9.4	imm		neg	neg	4080	0	ghost cells
4081	22-Aug	Skaha Lake	NSC	9.2	imm		neg	neg	4081	0	
4082	22-Aug	Skaha Lake	NSC	15.5	imm		neg	neg	4082	0	lymphocytes
4083	22-Aug	Skaha Lake	NSC	15.5	imm		neg	neg	4083	0	lymphocytes
4084	22-Aug	Skaha Lake	NSC	14.5	imm		neg	neg	4084	0	lymphocytes
4085	22-Aug	Skaha Lake	NSC	22.0	imm		neg	neg	4085	0	
4086	22-Aug	Skaha Lake	CHUB	29.4	imm	F	neg	neg	4086	0	
4087	22-Aug	Skaha Lake	CHUB	22.5	imm	M	neg	neg	4087	0	
4088	22-Aug	Skaha Lake	CHUB	28.6	imm	M	neg	neg	4088	0	
4089	22-Aug	Skaha Lake	CHUB	28.8	imm	F	neg	neg	4089	0	
4090	22-Aug	Skaha Lake	CHUB	27.0	imm	F	neg	neg	4090	1	
4091	22-Aug	Skaha Lake	CHUB	26.2	imm	F	neg	neg	4091	0	
4092	22-Aug	Skaha Lake	SU	12.6	imm		neg	neg	4092	0	
4093	22-Aug	Skaha Lake	SU	12.6	imm		neg	neg	4093	0	
4094	22-Aug	Skaha Lake	SU	13.0	imm		neg	neg	4094	0	
4095	22-Aug	Skaha Lake	SU	14.1	imm		neg	neg	4095	0	
4096	22-Aug	Skaha Lake	SU	11.9	imm		neg	neg	4096	0	lymphocytes
4097	22-Aug	Skaha Lake	SU	12.6	imm		neg	neg	4097	0	
4098	22-Aug	Skaha Lake	SU	35.2	imm	F	neg	neg	4098	0	ghpost cells
4099	22-Aug	Skaha Lake	SU	30.2	post spawn	M	neg	neg	4099	0	
4100	22-Aug	Skaha Lake	SU	10.4	imm		neg	neg	4100	0	no blood cells
4101	22-Aug	Skaha Lake	SU	14.2	imm		neg	neg	4101	0	
4102	22-Aug	Skaha Lake	SU	13.1	imm		neg	neg	4102	0	
4103	22-Aug	Skaha Lake	SU	15.2	imm		neg	neg	4103	0	lymphocytes
4104	22-Aug	Skaha Lake	RSC	5.2	imm		neg	neg	4104	0	
4105	22-Aug	Skaha Lake	RSC	6.2	imm		neg	neg	4105	0	no blood cells
4106	22-Aug	Skaha Lake	RSC	6.6	imm		neg	neg	4106	0	immature cells
4107	22-Aug	Skaha Lake	SMB	8.0			neg	neg	4107	0	
4108	22-Aug	Skaha Lake	SMB	7.1			neg	neg	4108	0	
4109	22-Aug	Skaha Lake	SMB	7.2			neg	neg	4109	0	immature cells
4110	22-Aug	Skaha Lake	SMB	8.2			neg	neg	4110	0	
4111	22-Aug	Skaha Lake	SMB	7.6			neg	neg	4111	0	
4112	22-Aug	Skaha Lake	SMB	15.6	imm		neg	neg	4112	0	immature cells
4113	22-Aug	Skaha Lake	SMB	17.4	imm		neg	neg	4113	0	
4114	22-Aug	Skaha Lake	SMB	16.4	imm		neg	neg	4114	0	
4115	22-Aug	Skaha Lake	SMB	7.0	imm		neg	neg	4115	0	
4116	22-Aug	Skaha Lake	SMB	6.4	imm		neg	neg	4116	0	
4117	22-Aug	Skaha Lake	SMB	6.9			neg	neg	4117	0	
4118	22-Aug	Skaha Lake	SMB	7.3	imm		neg	neg	4118	0	immature cells
4119	22-Aug	Skaha Lake	SMB	6.9			neg	neg	4119	0	
4120	22-Aug	Skaha Lake	SMB	7.5			neg	neg	4120	0	
4121	22-Aug	Skaha Lake	SMB	6.9			neg	neg	4121	0	
4122	22-Aug	Skaha Lake	SMB	7.7			neg	neg	4122	0	
4123	22-Aug	Skaha Lake	SMB	6.9			neg	neg	4123	0	
4124	22-Aug	Skaha Lake	SMB	7.0			neg	neg	4124	0	immature cells

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4125	22-Aug	Skaha Lake	SMB	6.1			neg	neg	4125	0	
4126	22-Aug	Skaha Lake	SMB	7.3			neg	neg	4126	0	
4127	22-Aug	Skaha Lake	SMB	7.7			neg	neg	4127	0	
4128	22-Aug	Skaha Lake	SMB	7.3			neg	neg	4128	0	
4129	22-Aug	Skaha Lake	SMB	7.5			neg	neg	4129	0	immature cells
4130	22-Aug	Skaha Lake	SMB	7.6			neg	neg	4130	0	
4131	27-Aug	Osoyoos Lake	BCB	7.2	imm		neg	neg	4131	0	
4132	27-Aug	Osoyoos Lake	BCB	8.3	imm		neg	neg	4132	0	
4133	27-Aug	Osoyoos Lake	BCB	8.4	imm		neg	neg	4133	0	
4134	27-Aug	Osoyoos Lake	PMB	6.6	imm		neg	neg	4134	0	
4135	27-Aug	Osoyoos Lake	PMB	9.0	imm		neg	neg	4135	0	lymphocytes
4136	27-Aug	Osoyoos Lake	PMB	9.7	imm		neg	neg	4136	0	
4137	27-Aug	Osoyoos Lake	PMB	8.6	imm		neg	neg	4137	0	
4138	27-Aug	Osoyoos Lake	PMB	5.2	imm		neg	neg	4138	0	
4139	27-Aug	Osoyoos Lake	PMB	8.4	imm		neg	neg	4139	0	
4140	27-Aug	Osoyoos Lake	PMB	8.5	imm		neg	neg	4140	0	
4141	27-Aug	Osoyoos Lake	PMB	9.7	imm	F	neg	neg	4141	0	lymphocytes
4142	27-Aug	Osoyoos Lake	PMB	16.4	imm	F	neg	neg	4142	0	
4143	27-Aug	Osoyoos Lake	PMB	18.9	imm	M	neg	neg	4143	0	
4144	27-Aug	Osoyoos Lake	BCB	6.7	imm	F	neg	neg	4144	0	
4145	27-Aug	Osoyoos Lake	PMB	7.5	imm	F	neg	neg	4145	0	
4146	27-Aug	Osoyoos Lake	PMB	8.0	imm		neg	neg	4146	0	
4147	27-Aug	Osoyoos Lake	PMB	8.3	imm	F	neg	neg	4147	0	
4148	27-Aug	Osoyoos Lake	PMB	9.1	imm	F	neg	neg	4148	0	
4149	27-Aug	Osoyoos Lake	PMB	10.3	imm	M	neg	neg	4149	0	
4150	27-Aug	Osoyoos Lake	PMB	8.3	imm		neg	neg	4150	0	
4151	27-Aug	Osoyoos Lake	PMB	6.8	imm	F	neg	neg	4151	0	
4152	27-Aug	Osoyoos Lake	PMB	7.4	imm		neg	neg	4152	0	
4153	27-Aug	Osoyoos Lake	PMB	7.6	imm		neg	neg	4153	0	
4154	27-Aug	Osoyoos Lake	PMB	8.3	imm		neg	neg	4154	0	
4155	27-Aug	Osoyoos Lake	PMB	9.2	imm	M	neg	neg	4155	0	
4156	27-Aug	Osoyoos Lake	PMB	10.9	imm		neg	neg	4156	0	
4157	27-Aug	Osoyoos Lake	PMB	10.6	imm		neg	neg	4157	0	
4158	27-Aug	Osoyoos Lake	LMB	8.1	imm		neg	neg	4158	0	immature cells
4159	27-Aug	Osoyoos Lake	LMB	7.5	imm		neg	neg	4159	0	
4160	27-Aug	Osoyoos Lake	LMB	8.8	imm		neg	neg	4160	0	
4161	27-Aug	Osoyoos Lake	LMB	8.8	imm		neg	neg	4161	0	
4162	27-Aug	Osoyoos Lake	LMB	11.1	imm		neg	neg	4162	0	immature cells
4163	27-Aug	Osoyoos Lake	LMB	10.5	imm		neg	neg	4163	0	
4164	27-Aug	Osoyoos Lake	LMB	9.0	imm		neg	neg	4164	0	
4165	27-Aug	Osoyoos Lake	SMB	10.5	imm		neg	neg	4165	0	
4166	27-Aug	Osoyoos Lake	SMB	11.1	imm		neg	neg	4166	0	
4167	27-Aug	Osoyoos Lake	LMB	6.4	imm		neg	neg	4167	0	
4168	27-Aug	Osoyoos Lake	LMB	6.8	imm		neg	neg	4168	0	
4169	27-Aug	Osoyoos Lake	LMB	7.5			neg	neg	4169	0	
4170	27-Aug	Osoyoos Lake	LMB	7.4	imm		neg	neg	4170	0	
4171	27-Aug	Osoyoos Lake	LMB	7.7			neg	neg	4171	1	
4172	27-Aug	Osoyoos Lake	SMB	10.4	imm	Imm	neg	neg	4172	0	
4173	27-Aug	Osoyoos Lake	LMB	12.0	imm	Imm	neg	neg	4173	0	
4174	27-Aug	Osoyoos Lake	LMB	8.5			neg	neg	4174	0	
4175	27-Aug	Osoyoos Lake	LMB	8.1	imm		neg	neg	4175	3	light blue color
4176	27-Aug	Osoyoos Lake	LMB	8.1	imm		neg	neg	4176	0	
4177	27-Aug	Osoyoos Lake	LMB	9.8	imm		neg	neg	4177	0	
4178	27-Aug	Osoyoos Lake	LMB	8.3	imm		neg	neg	4178	8	blue color, near nuclei
4179	27-Aug	Osoyoos Lake	LMB	9.7	imm		neg	neg	4179	0	
4180	27-Aug	Osoyoos Lake	SMB	10.5	imm		neg	neg	4180	0	
4181	27-Aug	Osoyoos Lake	LMB	10.0	imm		neg	neg	4181	0	
4182	27-Aug	Osoyoos Lake	LMB	11.5	imm		neg	neg	4182	0	
4183	27-Aug	Osoyoos Lake	SU	24.6	imm		neg	neg	4183	0	lymphocytes
4184	27-Aug	Osoyoos Lake	SU	22.4	imm		neg	neg	4184	0	
4185	27-Aug	Osoyoos Lake	SU	24.8	p-sp	M	neg	neg	4185	0	
4186	27-Aug	Osoyoos Lake	SU	23.9	imm		neg	neg	4186	0	lymphocytes
4187	27-Aug	Osoyoos Lake	SU	23.7	imm		neg	neg	4187	0	
4188	27-Aug	Osoyoos Lake	SU	23.2	imm		neg	neg	4188	0	
4189	27-Aug	Osoyoos Lake	SU	19.8	p-sp	M	neg	neg	4189	0	
4190	27-Aug	Osoyoos Lake	SU	18.0	imm		neg	neg	4190	0	
4191	27-Aug	Osoyoos Lake	SU	21.1	imm		neg	neg	4191	0	
4192	27-Aug	Osoyoos Lake	SU	20.0	imm	M	neg	neg	4192	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4193	27-Aug	Osoyoos Lake	SU	23.2	imm		neg	neg	4193	0	
4194	27-Aug	Osoyoos Lake	SU	19.8	p-sp	M	neg	neg	4194	0	
4195	27-Aug	Osoyoos Lake	SU	22.2	imm		neg	neg	4195	0	
4196	27-Aug	Osoyoos Lake	SU	24.0	imm		neg	neg	4196	0	
4197	27-Aug	Osoyoos Lake	SU	21.7	imm		neg	neg	4197	0	
4198	27-Aug	Osoyoos Lake	PMB	6.3	imm		neg	neg	4198	0	
4199	27-Aug	Osoyoos Lake	SMB	10.0	imm		neg	neg	4199	0	
4200	27-Aug	Osoyoos Lake	SMB	34.5	imm	F	neg	neg	4200	0	
4201	27-Aug	Osoyoos Lake	YP	12.7	imm		neg	neg	4201	0	
4202	27-Aug	Osoyoos Lake	YP	11.5	imm		neg	neg	4202	0	
4203	27-Aug	Osoyoos Lake	YP	13.7	imm		neg	neg	4203	0	
4204	27-Aug	Osoyoos Lake	YP	17.2	imm		neg	neg	4204	0	
4205	27-Aug	Osoyoos Lake	YP	20.3	imm		neg	neg	4205	0	lymphocytes
4206	28-Aug	Osoyoos Lake	BCB	7.0	imm		neg	neg	4206	0	
4207	28-Aug	Osoyoos Lake	BCB	7.1	imm		neg	neg	4207	0	
4208	28-Aug	Osoyoos Lake	BCB	6.7	imm		neg	neg	4208	0	
4209	28-Aug	Osoyoos Lake	BCB	7.5	imm		neg	neg	4209	0	
4210	28-Aug	Osoyoos Lake	PMB	7.7	imm		neg	neg	4210	0	
4211	28-Aug	Osoyoos Lake	BCB	8.2	imm		neg	neg	4211	0	
4212	28-Aug	Osoyoos Lake	PMB	8.7	imm	M	neg	neg	4212	0	
4213	28-Aug	Osoyoos Lake	PMB	6.8	imm	M	neg	neg	4213	0	
4214	28-Aug	Osoyoos Lake	BCB	8.1	imm		neg	neg	4214	0	
4215	28-Aug	Osoyoos Lake	BCB	8.7	imm		neg	neg	4215	0	
4216	28-Aug	Osoyoos Lake	PMB	8.6	imm	M	neg	neg	4216	0	
4217	28-Aug	Osoyoos Lake	PMB	9.9	imm	F	neg	neg	4217	0	
4218	28-Aug	Osoyoos Lake	BCB	13.2	imm		neg	neg	4218	0	
4219	28-Aug	Osoyoos Lake	BCB	11.2	imm		neg	neg	4219	4	
4220	28-Aug	Osoyoos Lake	PMB	7.2	imm		neg	neg	4220	0	
4221	28-Aug	Osoyoos Lake	PMB	7.7	imm		neg	neg	4221	0	
4222	28-Aug	Osoyoos Lake	PMB	7.9	imm		neg	neg	4222	0	
4223	28-Aug	Osoyoos Lake	PMB	8.9	imm	F	neg	neg	4223	0	
4224	28-Aug	Osoyoos Lake	PMB	9.8	imm		neg	neg	4224	0	
4225	28-Aug	Osoyoos Lake	PMB	10.9	imm	M	neg	neg	4225	0	
4226	28-Aug	Osoyoos Lake	PMB	10.2	imm	F	neg	neg	4226	0	
4227	28-Aug	Osoyoos Lake	PMB	11.4	imm	F	neg	neg	4227	0	
4228	28-Aug	Osoyoos Lake	SU	18.6	imm		neg	neg	4228	0	lymphocytes
4229	28-Aug	Osoyoos Lake	SU	19.9	imm		neg	neg	4229	0	
4230	28-Aug	Osoyoos Lake	SU	21.3	imm		neg	neg	4230	0	
4231	28-Aug	Osoyoos Lake	SU	17.8	imm		neg	neg	4231	0	lymphocytes
4232	28-Aug	Osoyoos Lake	SU	16.2	imm		neg	neg	4232	0	
4233	28-Aug	Osoyoos Lake	SU	21.1	imm		neg	neg	4233	0	
4234	28-Aug	Osoyoos Lake	SU	36.0	imm	M	neg	neg	4234	0	
4235	28-Aug	Osoyoos Lake	SU	23.5	imm		neg	neg	4235	0	
4236	28-Aug	Osoyoos Lake	SU	22.7	imm		neg	neg	4236	0	
4237	28-Aug	Osoyoos Lake	SU	17.8	imm		neg	neg	4237	0	
4238	28-Aug	Osoyoos Lake	SU	23.0	imm		neg	neg	4238	0	lymphocytes
4239	28-Aug	Osoyoos Lake	SU	22.1	imm		neg	neg	4239	0	
4240	28-Aug	Osoyoos Lake	SU	22.1	imm		neg	neg	4240	0	
4241	28-Aug	Osoyoos Lake	BCB	5.4	imm		neg	neg	4241	0	
4242	28-Aug	Osoyoos Lake	LMB	10.2	imm		neg	neg	4242	0	
4243	28-Aug	Osoyoos Lake	LMB	10.7	imm		neg	neg	4243	0	
4244	28-Aug	Osoyoos Lake	LMB	9.5	imm		neg	neg	4244	0	
4245	28-Aug	Osoyoos Lake	LMB	10.5	imm		neg	neg	4245	0	
4246	28-Aug	Osoyoos Lake	LMB	9.9	imm		neg	neg	4246	0	ghost cells
4247	28-Aug	Osoyoos Lake	LMB	10.9	imm		neg	neg	4247	0	
4248	28-Aug	Osoyoos Lake	LMB	24.0	imm	M?	neg	neg	4248	0	
4249	28-Aug	Osoyoos Lake	LMB	7.5	imm		neg	neg	4249	0	
4250	28-Aug	Osoyoos Lake	LMB	6.9	imm		neg	neg	4250	0	
4251	28-Aug	Osoyoos Lake	LMB	6.9	imm		neg	neg	4251	0	
4252	28-Aug	Osoyoos Lake	LMB	6.2	imm		neg	neg	4252	0	
4253	28-Aug	Osoyoos Lake	LMB	8.0	imm		neg	neg	4253	0	
4254	28-Aug	Osoyoos Lake	LMB	7.1	imm		neg	neg	4254	0	
4255	28-Aug	Osoyoos Lake	LMB	8.6	imm		neg	neg	4255	0	
4256	28-Aug	Osoyoos Lake	LMB	11.2	imm		neg	neg	4256	0	
4257	28-Aug	Osoyoos Lake	LMB	6.7	imm		neg	neg	4257	0	
4258	28-Aug	Osoyoos Lake	LMB	6.4	imm		neg	neg	4258	0	
4259	28-Aug	Osoyoos Lake	LMB	7.6	imm		neg	neg	4259	0	
4260	28-Aug	Osoyoos Lake	LMB	9.2	imm		neg	neg	4260	0	
4261	28-Aug	Osoyoos Lake	LMB	9.4	imm		neg	neg	4261	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4262	28-Aug	Osoyoos Lake	SMB	7.9	imm		neg	neg	4262	0	
4263	28-Aug	Osoyoos Lake	SMB	6.9	imm		neg	neg	4263	0	
4264	28-Aug	Osoyoos Lake	SMB	7.0	imm		neg	neg	4264	0	
4265	28-Aug	Osoyoos Lake	LMB	7.9	imm		neg	neg	4265	0	
4266	28-Aug	Osoyoos Lake	LMB	11.2	imm		neg	neg	4266	0	
4267	28-Aug	Osoyoos Lake	SMB	26.2	imm	M	neg	neg	4267	0	
4268	28-Aug	Osoyoos Lake	SMB	6.9	imm		neg	neg	4268	0	
4269	28-Aug	Osoyoos Lake	SMB	6.1	imm		neg	neg	4269	0	
4270	28-Aug	Osoyoos Lake	LMB	6.8	imm		neg	neg	4270	0	
4271	28-Aug	Osoyoos Lake	SMB	7.7	imm		neg	neg	4271	0	
4272	28-Aug	Osoyoos Lake	SMB	7.9	imm		neg	neg	4272	0	
4273	28-Aug	Osoyoos Lake	SMB	7.4	imm		neg	neg	4273	0	
4274	28-Aug	Osoyoos Lake	LMB	7.2	imm		neg	neg	4274	1	
4275	28-Aug	Osoyoos Lake	LMB	9.1	imm		neg	neg	4275	0	
4276	28-Aug	Osoyoos Lake	LMB	8.2	imm		neg	neg	4276	0	
4277	28-Aug	Osoyoos Lake	LMB	9.9	imm		neg	neg	4277	0	
4278	28-Aug	Osoyoos Lake	LMB	7.8	imm		neg	neg	4278	0	
4279	28-Aug	Osoyoos Lake	LMB	8.4	imm		neg	neg	4279	0	
4280	28-Aug	Osoyoos Lake	LMB	10.6	imm		neg	neg	4280	0	
4281	21-Sep	Okanagan Lk	KO	26.0	sp	F	pos	neg	4281	0	IHN pos carcass and ovarian fluid
4282	21-Sep	Okanagan Lk	KO	44.0	sp	M	neg	neg	4282	0	
4283	21-Sep	Okanagan Lk	KO	29.0	sp	M	neg	neg	4283	0	
4284	21-Sep	Okanagan Lk	KO	28.6	sp	F	pos	neg	4284	0	IHN pos ovarian fluid only
4285	21-Sep	Okanagan Lk	KO	28.3	sp	M	neg	neg	4285	0	
4286	21-Sep	Okanagan Lk	KO	28.9	sp	M	neg	neg	4286	0	
4287	21-Sep	Okanagan Lk	KO	25.9	sp	F	neg	neg	4287	0	
4288	21-Sep	Okanagan Lk	KO	27.9	sp	F	pos	neg	4288	0	IHN pos ovarian fluid only
4289	21-Sep	Okanagan Lk	KO	27.6	sp	M	neg	neg	4289	0	
4290	21-Sep	Okanagan Lk	KO	24.8	sp	M	pos	neg	4290	0	IHN pos carcass
4291	21-Sep	Okanagan Lk	KO	27.5	sp	M	pos	neg	4291	0	IHN pos carcass
4292	21-Sep	Okanagan Lk	KO	27.2	sp	F	pos	neg	4292	0	IHN positive ovarian fluid only
4293	21-Sep	Okanagan Lk	KO	34.0	sp	F	neg	neg	4293	0	
4294	21-Sep	Okanagan Lk	KO	26.5	sp	M	neg	neg	4294	0	
4295	21-Sep	Okanagan Lk	KO	28.0	sp	M	neg	neg	4295	0	
4296	21-Sep	Okanagan Lk	KO	24.6	sp	F	neg	neg	4296	0	
4297	21-Sep	Okanagan Lk	KO	26.9	sp	F	neg	neg	4297	0	
4298	21-Sep	Okanagan Lk	KO	25.4	sp	F	pos	neg	4298	0	IHN pos ovarian fluid only
4299	21-Sep	Okanagan Lk	KO	25.6	sp	F	neg	neg	4299	0	
4300	21-Sep	Okanagan Lk	KO	26.0	sp	F	neg	neg	4300	0	
4301	21-Sep	Okanagan Lk	KO	25.2	sp	F	neg	neg	4301	0	
4302	21-Sep	Okanagan Lk	KO	29.4	sp	M	neg	neg	4302	0	
4303	21-Sep	Okanagan Lk	KO	27.4	sp	F	pos	neg	4303	0	IHN pos ovarian fluid only
4304	21-Sep	Okanagan Lk	KO	49.0	sp	M	neg	neg	4304	0	
4305	21-Sep	Okanagan Lk	KO	44.0	sp	F	pos	neg	4305	0	IHN pos ovarian fluid only
4306	21-Sep	Okanagan Lk	KO	26.6	sp	F	pos	neg	4306	0	IHN pos ovarian fluid only
4307	21-Sep	Okanagan Lk	KO	25.0	sp	F	pos	neg	4307	0	IHN pos ovarian fluid only
4308	21-Sep	Okanagan Lk	KO	28.4	sp	F	pos	neg	4308	0	IHN pos ovarian fluid only
4309	21-Sep	Okanagan Lk	KO	20.5	sp	M	neg	neg	4309	0	
4310	21-Sep	Okanagan Lk	KO	25.6	sp	F	pos	neg	4310	0	IHN pos carcass
4311	21-Sep	Okanagan Lk	KO	49.0	sp	F	pos	neg	4311	0	IHN ovarian fluid only
4312	21-Sep	Okanagan Lk	KO	25.8	sp	F	pos	neg	4312	0	IHN pos carcass
4313	21-Sep	Okanagan Lk	KO	28.8	sp	M	pos	neg	4313	0	IHN pos carcass and ovarian fluid
4314	21-Sep	Okanagan Lk	KO	28.4	sp	F	pos	neg	4314	0	IHN pos carcass and ovarian fluid
4315	21-Sep	Okanagan Lk	KO	25.4	sp	F	pos	neg	4315	0	IHN pos carcass
4316	21-Sep	Okanagan Lk	KO	52.0	sp	M	neg	neg	4316	0	
4317	21-Sep	Okanagan Lk	KO	28.2	sp	F	neg	neg	4317	0	
4318	21-Sep	Okanagan Lk	KO	29.5	sp	F	pos	neg	4318	0	IHN pos carcass and ovarian fluid
4319	21-Sep	Okanagan Lk	KO	27.1	sp	M	neg	neg	4319	0	
4320	21-Sep	Okanagan Lk	KO	27.0	sp	F	pos	neg	4320	0	IHN pos carcass and ovarian fluid
4321	21-Sep	Okanagan Lk	KO	25.4	sp	F	pos	neg	4321	0	IHN pos carcass and ovarian fluid
4322	21-Sep	Okanagan Lk	KO	47.0	sp	M	pos	neg	4322	0	IHN pos carcass
4323	21-Sep	Okanagan Lk	KO	25.8	sp	F	pos	neg	4323	0	IHN pos carcass
4324	21-Sep	Okanagan Lk	KO	29.4	sp	F	pos	neg	4324	0	IHN pos carcass and ovarian fluid
4325	21-Sep	Okanagan Lk	KO	27.0	sp	M	neg	neg	4325	0	
4326	21-Sep	Okanagan Lk	KO	25.0	sp	F	pos	neg	4326	0	IHN pos carcass
4327	21-Sep	Okanagan Lk	KO	27.4	sp	M	pos	neg	4327	0	IHN pos carcass
4328	21-Sep	Okanagan Lk	KO	32.0	sp	M	pos	neg	4328	0	IHN pos carcass
4329	21-Sep	Okanagan Lk	KO	26.9	sp	F	pos	neg	4329	0	IHN pos carcass

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4330	21-Sep	Okanagan Lk	KO	28.5	sp	M	neg	neg	4330	0	
4331	21-Sep	Okanagan Lk	KO	26.4	sp	F	pos	neg	4331	0	IHN pos carcass
4332	21-Sep	Okanagan Lk	KO	26.5	sp	F	pos	neg	4332	0	IHN pos ovarian fluid only
4333	21-Sep	Okanagan Lk	KO	27.4	sp	F	pos	neg	4333	0	IHN positive carcass and ovarian fluid
4334	21-Sep	Okanagan Lk	KO	27.2	sp	M	neg	neg	4334	0	
4335	21-Sep	Okanagan Lk	KO	27.6	sp	F	pos	neg	4335	0	IHN pos carcass
4336	21-Sep	Okanagan Lk	KO	27.8	sp	F	pos	neg	4336	0	IHN pos carcass
4337	21-Sep	Okanagan Lk	KO	26.1	sp	F	pos	neg	4337	0	IHN pos carcass and ovarian fluid
4338	21-Sep	Okanagan Lk	KO	27.0	sp	F	pos	neg	4338	0	IHN pos carcass
4339	21-Sep	Okanagan Lk	KO	25.6	sp	F	pos	neg	4339	0	IHN carcass and ovarian fluid
4340	21-Sep	Okanagan Lk	KO	26.4	sp	F	pos	neg	4340	0	IHN pos ovarian fluid only
4341	21-Sep	Okanagan Lk	KO	25.1	sp	F	pos	neg	4341	0	IHN pos carcass and ovarian fluid
4342	21-Sep	Okanagan Lk	KO	26.4	sp	F	pos	neg	4342	0	IHN pos carcass
4343	21-Sep	Okanagan Lk	KO	26.8	sp	F	neg	neg	4343	0	
4344	24-Sep	Mission Creek	KO	26.4	sp	M	neg	neg	4344	0	
4345	24-Sep	Mission Creek	KO	25.5	sp	F	pos	neg	4345	0	IHN pos carcass
4346	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4346	0	IHN pos carcass and ovarian fluid
4347	24-Sep	Mission Creek	KO	26.5	sp	M	neg	neg	4347	0	
4348	24-Sep	Mission Creek	KO	27.5	sp	M	neg	neg	4348	0	
4349	24-Sep	Mission Creek	KO	36.0	sp	F	pos	neg	4349	0	IHN pos ovarian fluid only
4350	24-Sep	Mission Creek	KO	34.5	sp	M	pos	neg	4350	0	IHN pos carcass
4351	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4351	0	IHN pos carcass
4352	24-Sep	Mission Creek	KO	28.5	sp	F	pos	neg	4352	0	IHN pos carcass
4353	24-Sep	Mission Creek	KO	38.0	sp	M	neg	neg	4353	0	
4354	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4354	0	IHN pos carcass
4355	24-Sep	Mission Creek	KO	29.0	sp	M	neg	neg	4355	0	
4356	24-Sep	Mission Creek	KO	26.0	sp	M	neg	neg	4356	0	
4357	24-Sep	Mission Creek	KO	31.5	sp	F	pos	neg	4357	0	IHN pos carcass and ovarian fluid
4358	24-Sep	Mission Creek	KO	24.5	sp	F	pos	neg	4358	0	IHN pos carcass
4359	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4359	0	IHN pos carcass
4360	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4360	0	IHN pos carcass and ovarian fluid
4361	24-Sep	Mission Creek	KO	35.0	sp	M	pos	neg	4361	0	IHN pos carcass
4362	24-Sep	Mission Creek	KO	26.5	sp	F	pos	neg	4362	0	IHN pos carcass
4363	24-Sep	Mission Creek	KO	31.0	sp	M	pos	neg	4363	0	IHN pos carcass
4364	24-Sep	Mission Creek	KO	26.5	sp	M	neg	neg	4364	0	
4365	24-Sep	Mission Creek	KO	27.5	sp	F	pos	neg	4365	0	IHN pos carcass
4366	24-Sep	Mission Creek	KO	26.5	sp	F	pos	neg	4366	0	IHN pos carcass
4367	24-Sep	Mission Creek	KO	26.0	sp	F	neg	neg	4367	0	
4368	24-Sep	Mission Creek	KO	26.5	sp	M	neg	neg	4368	0	
4369	24-Sep	Mission Creek	KO	28.0	sp	F	neg	neg	4369	0	
4370	24-Sep	Mission Creek	KO	35.5	sp	F	pos	neg	4370	0	IHN pos carcass
4371	24-Sep	Mission Creek	KO	28.7	sp	F	pos	neg	4371	0	IHN pos carcass
4372	24-Sep	Mission Creek	KO	29.4	sp	M	neg	neg	4372	0	
4373	24-Sep	Mission Creek	KO	37.0	sp	M	pos	neg	4373	0	IHN pos carcass
4374	24-Sep	Mission Creek	KO	27.0	sp	F	pos	neg	4374	0	IHN pos carcass
4375	24-Sep	Mission Creek	KO	25.8	sp	M	neg	neg	4375	0	
4376	24-Sep	Mission Creek	KO	27.0	sp	M	neg	neg	4376	0	
4377	24-Sep	Mission Creek	KO	27.9	sp	F	pos	neg	4377	0	IHN pos carcass
4378	24-Sep	Mission Creek	KO	28.0	sp	F	pos	neg	4378	0	IHN pos ovarian fluid only
4379	24-Sep	Mission Creek	KO	27.5	sp	M	pos	neg	4379	0	IHN pos carcass
4380	24-Sep	Mission Creek	KO	27.8	sp	M	pos	neg	4380	0	IHN pos carcass
4381	24-Sep	Mission Creek	KO	26.5	sp	F	pos	neg	4381	0	IHN pos carcass
4382	24-Sep	Mission Creek	KO	40.3	sp	M	pos	neg	4382	0	IHN pos carcass
4383	24-Sep	Mission Creek	KO	30.7	sp	M	neg	neg	4383	0	
4384	24-Sep	Mission Creek	KO	38.6	sp	F	pos	neg	4384	0	IHN pos carcass
4385	24-Sep	Mission Creek	KO	27.5	sp	F	pos	neg	4385	0	IHN pos carcass
4386	24-Sep	Mission Creek	KO	26.5	sp	F	pos	neg	4386	0	IHN pos carcass
4387	24-Sep	Mission Creek	KO	27.0	sp	M	neg	neg	4387	0	
4388	24-Sep	Mission Creek	KO	38.5	sp	M	pos	neg	4388	0	IHN pos carcass
4389	24-Sep	Mission Creek	KO	27.0	sp	F	neg	neg	4389	0	
4390	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4390	0	IHN pos carcass and ovarian fluid
4391	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4391	0	IHN pos carcass and ovarian fluid
4392	24-Sep	Mission Creek	KO	25.5	sp	F	pos	neg	4392	0	IHN pos carcass and ovarian fluid
4393	24-Sep	Mission Creek	KO		sp	M	pos	neg	4393	0	IHN pos carcass
4394	24-Sep	Mission Creek	KO		sp	M	neg	neg	4394	0	
4395	24-Sep	Mission Creek	KO		sp	F	neg	neg	4395	0	
4396	24-Sep	Mission Creek	KO		sp	F	pos	neg	4396	0	IHN pos carcass and ovarian fluid

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4397	24-Sep	Mission Creek	KO		sp	F	pos	neg	4397	0	IHN pos carcass
4398	24-Sep	Mission Creek	KO		sp	F	pos	neg	4398		IHN pos carcass and ovarian fluid, no blood smear
4399	24-Sep	Mission Creek	KO	25.0	sp	F	neg	neg	4399	0	
4400	24-Sep	Mission Creek	KO	27.5	sp	F	pos	neg	4400	0	IHN pos carcass
4401	24-Sep	Mission Creek	KO	32.5	sp	F	pos	neg	4401	0	IHN pos carcass
4402	24-Sep	Mission Creek	KO	28.0	sp	F	pos	neg	4402	0	IHN pos carcass and ovarian fluid
4403	24-Sep	Mission Creek	KO	27.6	sp	M	neg	neg	4403	0	
4404	24-Sep	Mission Creek	KO	29.0	sp	M	pos	neg	4404	0	IHN pos carcass
4405	24-Sep	Mission Creek	KO	28.6	sp	F	neg	neg	4405	0	
4406	24-Sep	Mission Creek	KO	31.6	sp	M	neg	neg	4406	0	
4407	24-Sep	Mission Creek	KO	27.7	sp	F	pos	neg	4407	0	IHN pos carcasses and ovaian fluid
4408	24-Sep	Mission Creek	KO	27.8	sp	M	neg	neg	4408	0	
4409	24-Sep	Mission Creek	KO	26.0	sp	F	pos	neg	4409	0	IHN pos carcass
4410	24-Sep	Mission Creek	KO	27.0	sp	F	pos	neg	4410	0	IHN pos carcasses and ovarians
4411	24-Sep	Mission Creek	KO	27.8	sp	F	pos	neg	4411	0	IHN pos carcasses and ovarians
4412	24-Sep	Mission Creek	KO	29.1	sp	M	pos	neg	4412	0	IHN pos carcass
4413	26-Sep	Deep Creek	KO		sp	M	pos	neg	4413	0	IHN pos carcasses and ovarians
4414	26-Sep	Deep Creek	KO	26.5	sp	F	pos	neg	4414	0	IHN pos carcasses and ovarians
4415	26-Sep	Deep Creek	KO		sp	F	pos	neg	4415	0	IHN pos carcasses and ovarians
4416	26-Sep	Deep Creek	KO		sp	F	pos	neg	4416	0	IHN pos carcasses and ovarians
4417	26-Sep	Deep Creek	KO		sp	F	pos	neg	4417	0	IHN pos carcasses and ovarians
4418	26-Sep	Deep Creek	KO	29.6	sp	M	pos	neg	4418	0	IHN pos carcasses and ovarians
4419	26-Sep	Deep Creek	KO	27.0	sp	F	pos	neg	4419	0	IHN pos carcasses and ovarians
4420	26-Sep	Deep Creek	KO	29.0	sp	M	pos	neg	4420	0	IHN pos carcasses and ovarians
4421	26-Sep	Deep Creek	KO	30.9	sp	F	pos	neg	4421	0	IHN pos carcasses and ovarians
4422	26-Sep	Deep Creek	KO	26.5	sp	F	pos	neg	4422	0	IHN pos carcasses and ovarians
4423	26-Sep	Deep Creek	KO	26.7	sp	F	pos	neg	4423	0	IHN pos carcasses and ovarians
4424	26-Sep	Deep Creek	KO	25.5	sp	F	pos	neg	4424	0	IHN pos carcasses and ovarians
4425	26-Sep	Deep Creek	KO	25.5	sp	F	pos	neg	4425	0	IHN pos carcasses and ovarians
4426	26-Sep	Deep Creek	KO	25.5	sp	M	pos	neg	4426	0	IHN pos carcasses and ovarians
4427	26-Sep	Deep Creek	KO	26.4	sp	F	pos	neg	4427	0	IHN pos carcasses and ovarians
4428	26-Sep	Deep Creek	KO	26.1	sp	F	pos	neg	4428	0	IHN pos carcasses and ovarians
4429	26-Sep	Deep Creek	KO	28.6	sp	F	pos	neg	4429	0	IHN pos carcasses and ovarians
4430	26-Sep	Deep Creek	KO	40.5	sp	F	pos	neg	4430	0	IHN pos carcasses and ovarians
4431	2-Oct	Okanogan Lk	KO	5.8	juv		neg	neg	4431	0	
4432	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4432	0	
4433	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4433	0	
4434	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4434	0	
4435	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4435	0	
4436	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4436	0	
4437	2-Oct	Okanogan Lk	KO	6.2	juv		neg	neg	4437	0	
4438	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4438	0	
4439	2-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4439	0	
4440	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4440	0	
4441	2-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4441	0	
4442	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4442	0	
4443	2-Oct	Okanogan Lk	KO	5.9	juv		neg	neg	4443	0	
4444	2-Oct	Okanogan Lk	KO	5.9	juv		neg	neg	4444	0	
4445	2-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4445	0	
4446	2-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4446	0	
4447	2-Oct	Okanogan Lk	KO	6.1	juv		neg	neg	4447	0	
4448	2-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4448	0	
4449	2-Oct	Okanogan Lk	KO	6.7	juv		neg	neg	4449	0	
4450	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4450	0	
4451	2-Oct	Okanogan Lk	KO	6.3	juv		neg	neg	4451	0	
4452	2-Oct	Okanogan Lk	KO	5.8	juv		neg	neg	4452	0	
4453	2-Oct	Okanogan Lk	KO	5.7	juv		neg	neg	4453	0	
4454	2-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4454	0	
4455	2-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4455	0	
4456	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4456	0	
4457	2-Oct	Okanogan Lk	KO	6.2	juv		neg	neg	4457	0	
4458	2-Oct	Okanogan Lk	KO	8.3	juv		neg	neg	4458	0	
4459	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4459	0	
4460	2-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4460	0	
4461	2-Oct	Okanogan Lk	KO	7.5	juv		neg	neg	4461	0	
4462	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4462	0	
4463	2-Oct	Okanogan Lk	KO	5.6	juv		neg	neg	4463	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4464	2-Oct	Okanogan Lk	KO	6.2	juv		neg	neg	4464	0	
4465	2-Oct	Okanogan Lk	KO	6.0	juv		neg	neg	4465	0	
4466	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4466	0	
4467	2-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4467	0	
4468	2-Oct	Okanogan Lk	KO	7.7	juv		neg	neg	4468	0	
4469	2-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4469	0	
4470	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4470	0	
4471	2-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4471	0	
4472	2-Oct	Okanogan Lk	KO	7.4	juv		neg	neg	4472	0	
4473	2-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4473	0	
4474	2-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4474	0	
4475	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4475	0	
4476	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4476	0	
4477	2-Oct	Okanogan Lk	KO	6.3	juv		neg	neg	4477	0	
4478	2-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4478	0	
4479	2-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4479	0	
4480	2-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4480	0	
4481	2-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4481	0	
4482	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4482	0	
4483	2-Oct	Okanogan Lk	KO	6.7	juv		neg	neg	4483	0	
4484	2-Oct	Okanogan Lk	KO	7.7	juv		neg	neg	4484	0	
4485	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4485	0	
4486	2-Oct	Okanogan Lk	KO	7.6	juv		neg	neg	4486	0	
4487	2-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4487	0	
4488	2-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4488	0	
4489	2-Oct	Okanogan Lk	KO	8.0	juv		neg	neg	4489	0	
4490	2-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4490	0	
4491	2-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4491	0	
4492	2-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4492	0	
4493	2-Oct	Okanogan Lk	KO	7.7	juv		neg	neg	4493	0	
4494	2-Oct	Okanogan Lk	KO	6.7	juv		neg	neg	4494	0	
4495	2-Oct	Okanogan Lk	KO	8.1	juv		neg	neg	4495	0	
4496	2-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4496	0	
4497	2-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4497	0	
4498	2-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4498	0	
4499	2-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4499	0	
4500	2-Oct	Okanogan Lk	KO	7.8	juv		neg	neg	4500	0	
4501	2-Oct	Okanogan Lk	KO	8.3	juv		neg	neg	4501	0	
4502	2-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4502	0	
4503	2-Oct	Okanogan Lk	KO	6.3	juv		neg	neg	4503	0	
4504	2-Oct	Okanogan Lk	KO	7.6	juv		neg	neg	4504	0	
4505	2-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4505	0	
4506	15-Oct	Okanogan Lk	KO	7.4	juv		neg	neg	4506	0	
4507	15-Oct	Okanogan Lk	KO	7.4	juv		neg	neg	4507	0	
4508	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4508	0	
4509	15-Oct	Okanogan Lk	KO	7.4	juv		neg	neg	4509	0	
4510	15-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4510	0	
4511	15-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4511	0	
4512	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4512	0	
4513	15-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4513	0	
4514	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4514	0	
4515	15-Oct	Okanogan Lk	KO	6.7	juv		neg	neg	4515	0	
4516	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4516	0	
4517	15-Oct	Okanogan Lk	KO	8.0	juv		neg	neg	4517	0	
4518	15-Oct	Okanogan Lk	KO	6.4	juv		neg	neg	4518	0	
4519	15-Oct	Okanogan Lk	KO	6.8	juv		neg	neg	4519	0	
4520	15-Oct	Okanogan Lk	KO	6.2	juv		neg	neg	4520	0	
4521	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4521	0	
4522	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4522	0	
4523	15-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4523	0	
4524	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4524	0	
4525	15-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4525	0	
4526	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4526	0	
4527	15-Oct	Okanogan Lk	KO	6.9	juv		neg	neg	4527	0	
4528	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4528	0	
4529	15-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4529	0	
4530	15-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4530	0	
4531	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4531	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4532	15-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4532	0	
4533	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4533	0	
4534	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4534	0	
4535	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4535	0	
4536	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4536	0	
4537	15-Oct	Okanogan Lk	KO	7.9	juv		neg	neg	4537	0	
4538	15-Oct	Okanogan Lk	KO	8.2	juv		neg	neg	4538	0	
4539	15-Oct	Okanogan Lk	KO	8.0	juv		neg	neg	4539	0	
4540	15-Oct	Okanogan Lk	KO	8.0	juv		neg	neg	4540	0	
4541	15-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4541	0	
4542	15-Oct	Okanogan Lk	KO		juv		neg	neg	4542	0	
4543	15-Oct	Okanogan Lk	KO	7.8	juv		neg	neg	4543	0	
4544	15-Oct	Okanogan Lk	KO		juv		neg	neg	4544	0	
4545	15-Oct	Okanogan Lk	KO		juv		neg	neg	4545	0	
4546	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4546	0	
4547	15-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4547	0	
4548	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4548	0	
4549	15-Oct	Okanogan Lk	KO	7.1	juv		neg	neg	4549	0	
4550	15-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4550	0	
4551	15-Oct	Okanogan Lk	KO	6.7	juv		neg	neg	4551	0	
4552	15-Oct	Okanogan Lk	KO	7.5	juv		neg	neg	4552	0	
4553	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4553	0	
4554	15-Oct	Okanogan Lk	KO	8.2	juv		neg	neg	4554	0	
4555	15-Oct	Okanogan Lk	KO	8.2	juv		neg	neg	4555	0	
4556	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4556	0	
4557	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4557	0	
4558	15-Oct	Okanogan Lk	KO	6.2	juv		neg	neg	4558	0	
4559	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4559	0	
4560	15-Oct	Okanogan Lk	KO	7.4	juv		neg	neg	4560	0	
4561	15-Oct	Okanogan Lk	KO	7.0	juv		neg	neg	4561	0	
4562	15-Oct	Okanogan Lk	KO	7.2	juv		neg	neg	4562	0	
4563	15-Oct	Okanogan Lk	KO		juv		neg	neg	4563	0	
4564	15-Oct	Okanogan Lk	KO		juv		neg	neg	4564	0	
4565	15-Oct	Okanogan Lk	KO	7.7	juv		neg	neg	4565	0	
4566	15-Oct	Okanogan Lk	KO	7.4	juv		neg	neg	4566	0	
4567	15-Oct	Okanogan Lk	KO	8.1	juv		neg	neg	4567	0	
4568	15-Oct	Okanogan Lk	KO		juv		neg	neg	4568	0	
4569	15-Oct	Okanogan Lk	KO	7.5	juv		neg	neg	4569	0	
4570	15-Oct	Okanogan Lk	KO		juv		neg	neg	4570	0	
4571	15-Oct	Okanogan Lk	KO	7.8	juv		neg	neg	4571	0	
4572	15-Oct	Okanogan Lk	KO	7.6	juv		neg	neg	4572	0	
4573	15-Oct	Okanogan Lk	KO	6.5	juv		neg	neg	4573	0	
4574	15-Oct	Okanogan Lk	KO	6.6	juv		neg	neg	4574	0	
4575	15-Oct	Okanogan Lk	KO	8.1	juv		neg	neg	4575	0	
4576	15-Oct	Okanogan Lk	KO	7.3	juv		neg	neg	4576	0	
4577	15-Oct	Okanogan Lk	KO	8.8	juv		neg	neg	4577	0	
4578	15-Oct	Okanogan Lk	KO	7.6	juv		neg	neg	4578	0	
4579	15-Oct	Okanogan Lk	KO		juv		neg	neg	4579	0	
4580	15-Oct	Okanogan Lk	KO	7.5	juv		neg	neg	4580	0	
4581	14-Nov	Okanogan Lk	WF	11.4	juv		neg	neg	4581	0	
4582	14-Nov	Okanogan Lk	WF	11.1	juv		neg	neg	4582	0	
4583	14-Nov	Okanogan Lk	WF	12.3	juv		neg	neg	4583	0	
4584	14-Nov	Okanogan Lk	WF	12.0	juv		neg	neg	4584	0	
4585	14-Nov	Okanogan Lk	WF	12.1	juv		neg	neg	4585	0	
4586	14-Nov	Okanogan Lk	WF	12.9	juv		neg	neg	4586	0	
4587	14-Nov	Okanogan Lk	WF	11.9	juv		neg	neg	4587	0	
4588	14-Nov	Okanogan Lk	WF	11.5	juv		neg	neg	4588	0	
4589	14-Nov	Okanogan Lk	WF	13.2	juv		neg	neg	4589	0	
4590	14-Nov	Okanogan Lk	WF	10.3	juv		neg	neg	4590	0	
4591	14-Nov	Okanogan Lk	WF	12.9	juv		neg	neg	4591	0	
4592	14-Nov	Okanogan Lk	WF	11.3	juv		neg	neg	4592	0	
4592b	16-Nov	Osoyoos Lake	WF	18.0	imm		neg	neg	4592b	0	
4593	16-Nov	Osoyoos Lake	WF	15.7	imm		neg	neg	4593	0	
4594	16-Nov	Osoyoos Lake	WF	17.3	imm		neg	neg	4594	0	
4595	16-Nov	Osoyoos Lake	WF	23.2	imm	F	neg	neg	4595	0	
4596	16-Nov	Osoyoos Lake	WF	27.2	imm	F	neg	neg	4596	0	
4597	16-Nov	Osoyoos Lake	SU	25.4	imm		neg	neg	4597	0	
4598	16-Nov	Osoyoos Lake	SU	24.3	imm		neg	neg	4598	0	
4599	16-Nov	Osoyoos Lake	SU	47.0	sp	F	neg	neg	4599	0	

Fish No.	Date 2001	Location	Species	Length (cm)	Age	Sex	IHN Positive Fish	IPNV Positive Fish	Blood Smear Slide No.	Number of Inclusion	Comments
4600	16-Nov	Osoyoos Lake	SU	25.2	sp	F	neg	neg	4600	0	
4601	16-Nov	Osoyoos Lake	SU	48.4	sp	F	neg	neg	4601	0	
4602	16-Nov	Osoyoos Lake	SU	24.7	imm		neg	neg	4602	0	
4603	16-Nov	Osoyoos Lake	SU	20.7	imm		neg	neg	4603	0	
4604	16-Nov	Osoyoos Lake	SU	48.2	sp	F	neg	neg	4604	0	
4605	16-Nov	Osoyoos Lake	SMB	49.5	sp	F	neg	neg	4605	0	
4606	16-Nov	Osoyoos Lake	SMB	10.0	juv		neg	neg	4606	0	
4607	16-Nov	Osoyoos Lake	WF	10.8	juv		neg	neg	4607	0	
4608	16-Nov	Osoyoos Lake	WF	12.8	juv		neg	neg	4608	1	
4609	16-Nov	Osoyoos Lake	WF	12.2	juv		neg	neg	4609	0	
4610	16-Nov	Osoyoos Lake	WF	13.1	juv		neg	neg	4610	0	
4611	16-Nov	Osoyoos Lake	WF	12.0	juv		neg	neg	4611	0	
4612	16-Nov	Osoyoos Lake	WF	15.8	juv		neg	neg	4612	0	
4613	16-Nov	Osoyoos Lake	WF	17.2	juv		neg	neg	4613	0	
4614	16-Nov	Osoyoos Lake	WF	15.5	juv		neg	neg	4614	0	
4615	16-Nov	Osoyoos Lake	WF	18.2	juv		neg	neg	4615	0	
4616	16-Nov	Osoyoos Lake	WF	15.0	juv		neg	neg	4616	0	
4617	16-Nov	Osoyoos Lake	WF	18.4	juv		neg	neg	4617	0	
4618	16-Nov	Osoyoos Lake	WF	24.1	imm	F	neg	neg	4618	1	
4619	16-Nov	Osoyoos Lake	WF	29.0	imm	F	neg	neg	4619	0	
4620	16-Nov	Osoyoos Lake	WF	32.1	psp	F	neg	neg	4620	0	
4621	16-Nov	Osoyoos Lake	WF	34.2	sp	M	neg	neg	4621	0	
4622	16-Nov	Osoyoos Lake	WF	34.8	sp	M	neg	neg	4622	0	
4623	16-Nov	Osoyoos Lake	WF	34.8	sp	F	neg	neg	4623	0	
4624	16-Nov	Osoyoos Lake	WF	17.3	juv		neg	neg	4624	0	
4625	16-Nov	Osoyoos Lake	WF	15.0	juv		neg	neg	4625	0	
4626	16-Nov	Osoyoos Lake	WF	12.0	imm		neg	neg	4626	0	
4627	16-Nov	Osoyoos Lake	WF	11.1	juv		neg	neg	4627	0	
4628	16-Nov	Osoyoos Lake	WF	15.0	imm		neg	neg	4628	0	
4629	16-Nov	Osoyoos Lake	WF	13.3	imm		neg	neg	4629	0	
4630	16-Nov	Osoyoos Lake	WF	14.5	juv		neg	neg	4630	0	
4631	16-Nov	Osoyoos Lake	WF	15.8	imm		neg	neg	4631	0	

Table 2. Detection of *Myxosoma cerebralis* (whirling disease) by Pepsin-Trypsin Digest Method

Results from live fish remaining after 150 day grow out period at Skaha Hatchery.
Live box exposure field study took place in May 2001.

Site #	Fish #'s	# pools	Pepsin digest	Trypsin Digest	Glucose centrifigation	Date read	Read by
Control Grp 1	1-100	20	neg	neg	neg	27/12/2001	Sherry Guest
Control Grp 2	101-191	18	neg	neg	neg	04/01/2002	Sherry Guest
Site 1	192-264	15	neg	neg	neg	08/01/2002	Sherry Guest
Site 2	265-320	11	neg	neg	neg	11/01/2002	Sherry Guest
Site 3	321-405	17	neg	neg	neg	18/01/2002	Sherry Guest
Site 4	406-495	18	neg	neg	neg	23/01/2002	Sherry Guest
Site 5	496-552	12	neg	neg	neg	28/01/2002	Sherry Guest
Site 6	553-615	13	neg	neg	neg	24/01/2002	Sherry Guest
Site 7	lost in field						
Site 8	616-709	19	neg	neg	neg	04/02/2002	Sherry Guest

* All samples pooled in 5's or less where applicable.

** mortality results will be appended later this week

APPENDIX B

Department of Fisheries and Oceans
Canada Laboratory Results

Table 1. Results of pathogen survey of Okanagan River sockeye salmon 2001.

Date 2001	Sample	Site	Virus assay	Blood smear	C. shasta	M. cerebralis
Feb 7	Emergent fry	Okanagan Rv	0/60	ns*	ns*	ns*
Feb 14	Emergent fry	Okanagan Rv	0/60	ns	ns	ns
Feb 21	Emergent fry	Okanagan Rv	0/60	ns	ns	ns
Feb 27	Emergent fry	Okanagan Rv	0/60	ns	ns	ns
Mar 6	Emergent fry	Okanagan Rv	0/60	ns	ns	ns
Mar 13	Emergent fry	Okanagan Rv	0/60	ns	ns	ns
Mar 25	Emergent fry	Okanagan Rv	0/30	ns	ns	ns
Apr 4	Emergent fry	Okanagan Rv	0/60	ns	ns	ns
Apr 18	Emergent fry	Okanagan Rv	0/65	ns	ns	ns
Jun 11	Fry	Osoyoos Lake	0/60	ns	ns	ns
Jun 12	Fry	Osoyoos Lake	0/60	ns	ns	ns
Jun 13	Fry	Osoyoos Lake	0/60	ns	ns	ns
Oct 16	Adults	Okanagan Rv	62/183	0/49	0/183	0/163
Nov 28	Fry	Osoyoos Lake	0/60	ns	ns	ns

* not sampled

One spawning adult sockeye with multifocal grayish lesions in the kidney was positive for *Renibacterium salmoninarum* by DFAT

Table 2. Titer and prevalence of infectious hematopoietic necrosis virus (IHNV) detected in post-spawned sockeye salmon from the Okanagan River in 2001.

Virus titer Pfu/ml	Females		Males		Total	
	Ovarian fluid	Kidney	Milt	Kidney	Reproductive fluid	Kidney
No virus detected	50	60	101	80	151	140
10 ²	6	6	3	7	9	13
10 ³	8	3	1	3	9	6
10 ⁴	7	3	1	8	8	11
10 ⁵	3	1	1	6	4	7
10 ⁶	1	3	1	3	2	6
Total	25/75	16/76	7/108	27/107	32/183	40/183
Prevalence	33.3%	21.1%	6.5%	25.2%	17.5%	21.9%

A total of 24 IHNV isolates were tested with an indirect fluorescent antibody technique (IFAT) and all reacted positively with the universal IHNV Mab and did not react with either the 105B (type 2 specific) or E5 (IPNV inuversal antibody.)

Table 3. Summary of pathogen survey of sockeye salmon in 2000 and 2001 from the Okanagan River basin.

	Virus Assay	Blood Smear EIBS	Ceratomyxa shasta	Myxosoma cerebralis
2000				
Fry	0/248	0/138	Not sampled	Not sampled
Adults	114/208*	0/53	0/158	0/205
2001				
Emergent fry	0/521	Not sampled	Not sampled	Not sampled
Fry	0/240	Not sampled	Not sampled	Not sampled
Adults	62/183	0/49	0/183	0/163

* all isolates infectious hematopoietic necrosis virus

A total of 75 IHNV isolates tested with indirect fluorescent technique (IFAT). All reacted positively with the universal IHNV Mab and did not react with the 105B Type 2 specific Mab.

Table 4. Results of pathogen survey of sockeye yolk sac fry

Collection Site- Okanagan River Collection Date-February 7, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay -March 22, 2001 (samples frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-February 14, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-February 16, 2001 (samples not frozen) Cell lines-EPC and CHSE-215	Collection Site- Okanagan River Collection Date-February 21, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-February 23, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-February 27, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-March 1, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-March 6, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-March 8, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-March 13, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-March 15, 2001 (samples not frozen) Cell lines-EPC and CHSE-214
---	--	--	--	--	--

Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results
1	1	*nvd	1	1	*nvd	1	1	*nvd	1	1	*nvd	1	1	*nvd	1	1	*nvd
2	1	nvd	2	1	nvd	2	1	nvd	2	1	nvd	2	1	nvd	2	1	nvd
3	1	nvd	3	1	nvd	3	1	nvd	3	1	nvd	3	1	nvd	3	1	nvd
4	1	nvd	4	1	nvd	4	1	nvd	4	1	nvd	4	1	nvd	4	1	nvd
5	1	nvd	5	1	nvd	5	1	nvd	5	1	nvd	5	1	nvd	5	1	nvd
6	1	nvd	6	1	nvd	6	1	nvd	6	1	nvd	6	1	nvd	6	1	nvd
7	1	nvd	7	1	nvd	7	1	nvd	7	1	nvd	7	1	nvd	7	1	nvd
8	1	nvd	8	1	nvd	8	1	nvd	8	1	nvd	8	1	nvd	8	1	nvd
9	1	nvd	9	1	nvd	9	1	nvd	9	1	nvd	9	1	nvd	9	1	nvd
10	1	nvd	10	1	nvd	10	1	nvd	10	1	nvd	10	1	nvd	10	1	nvd
11	1	nvd	11	1	nvd	11	1	nvd	11	1	nvd	11	1	nvd	11	1	nvd
12	1	nvd	12	1	nvd	12	1	nvd	12	1	nvd	12	1	nvd	12	1	nvd
13	1	nvd	13	1	nvd	13	1	nvd	13	1	nvd	13	1	nvd	13	1	nvd
14	1	nvd	14	1	nvd	14	1	nvd	14	1	nvd	14	1	nvd	14	1	nvd
15	1	nvd	15	1	nvd	15	1	nvd	15	1	nvd	15	1	nvd	15	1	nvd
16	1	nvd	16	1	nvd	16	1	nvd	16	1	nvd	16	1	nvd	16	1	nvd
17	1	nvd	17	1	nvd	17	1	nvd	17	1	nvd	17	1	nvd	17	1	nvd
18	1	nvd	18	1	nvd	18	1	nvd	18	1	nvd	18	1	nvd	18	1	nvd
19	1	nvd	19	1	nvd	19	1	nvd	19	1	nvd	19	1	nvd	19	1	nvd
20	1	nvd	20	1	nvd	20	1	nvd	20	1	nvd	20	1	nvd	20	1	nvd
21	1	nvd	21	1	nvd	21	1	nvd	21	1	nvd	21	1	nvd	21	1	nvd
22	1	nvd	22	1	nvd	22	1	nvd	22	1	nvd	22	1	nvd	22	1	nvd
23	1	nvd	23	1	nvd	23	1	nvd	23	1	nvd	23	1	nvd	23	1	nvd
24	1	nvd	24	1	nvd	24	1	nvd	24	1	nvd	24	1	nvd	24	1	nvd
25	1	nvd	25	1	nvd	25	1	nvd	25	1	nvd	25	1	nvd	25	1	nvd
26	1	nvd	26	1	nvd	26	1	nvd	26	1	nvd	26	1	nvd	26	1	nvd
27	1	nvd	27	1	nvd	27	1	nvd	27	1	nvd	27	1	nvd	27	1	nvd
28	1	nvd	28	1	nvd	28	1	nvd	28	1	nvd	28	1	nvd	28	1	nvd
29	1	nvd	29	1	nvd	29	1	nvd	29	1	nvd	29	1	nvd	29	1	nvd

Cont. Table 4. Results of pathogen survey of sockeye yolk sac fry

Collection Site- Okanagan River Collection Date-February 7, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay -March 22, 2001 (samples frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-February 14, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-February 16, 2001 (samples not frozen) Cell lines-EPC and CHSE-215	Collection Site- Okanagan River Collection Date-February 21, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-February 23, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-February 27, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-March 1, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-March 6, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-March 8, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-March 13, 2001 Sample-60 sockeye yolk-sac fry (1-30 transect 2/3, 31-60 transect 7) Assay Date-March 15, 2001 (samples not frozen) Cell lines-EPC and CHSE-214
--	--	--	--	--	--

Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results
30	1	nvd	30	1	nvd	30	1	nvd	30	1	nvd	30	1	nvd	30	1	nvd
31	1	nvd	31	1	nvd	31	1	nvd	31	1	nvd	31	1	nvd	31	1	nvd
32	1	nvd	32	1	nvd	32	1	nvd	32	1	nvd	32	1	nvd	32	1	nvd
33	1	nvd	33	1	nvd	33	1	nvd	33	1	nvd	33	1	nvd	33	1	nvd
34	1	nvd	34	1	nvd	34	1	nvd	34	1	nvd	34	1	nvd	34	1	nvd
35	1	nvd	35	1	nvd	35	1	nvd	35	1	nvd	35	1	nvd	35	1	nvd
36	1	nvd	36	1	nvd	36	1	nvd	36	1	nvd	36	1	nvd	36	1	nvd
37	1	nvd	37	1	nvd	37	1	nvd	37	1	nvd	37	1	nvd	37	1	nvd
38	1	nvd	38	1	nvd	38	1	nvd	38	1	nvd	38	1	nvd	38	1	nvd
39	1	nvd	39	1	nvd	39	1	nvd	39	1	nvd	39	1	nvd	39	1	nvd
40	1	nvd	40	1	nvd	40	1	nvd	40	1	nvd	40	1	nvd	40	1	nvd
41	1	nvd	41	1	nvd	41	1	nvd	41	1	nvd	41	1	nvd	41	1	nvd
42	1	nvd	42	1	nvd	42	1	nvd	42	1	nvd	42	1	nvd	42	1	nvd
43	1	nvd	43	1	nvd	43	1	nvd	43	1	nvd	43	1	nvd	43	1	nvd
44	1	nvd	44	1	nvd	44	1	nvd	44	1	nvd	44	1	nvd	44	1	nvd
45	1	nvd	45	1	nvd	45	1	nvd	45	1	nvd	45	1	nvd	45	1	nvd
46	1	nvd	46	1	nvd	46	1	nvd	46	1	nvd	46	1	nvd	46	1	nvd
47	1	nvd	47	1	nvd	47	1	nvd	47	1	nvd	47	1	nvd	47	1	nvd
48	1	nvd	48	1	nvd	48	1	nvd	48	1	nvd	48	1	nvd	48	1	nvd
49	1	nvd	49	1	nvd	49	1	nvd	49	1	nvd	49	1	nvd	49	1	nvd
50	1	nvd	50	1	nvd	50	1	nvd	50	1	nvd	50	1	nvd	50	1	nvd
51	1	nvd	51	1	nvd	51	1	nvd	51	1	nvd	51	1	nvd	51	1	nvd
52	1	nvd	52	1	nvd	52	1	nvd	52	1	nvd	52	1	nvd	52	1	nvd
53	1	nvd	53	1	nvd	53	1	nvd	53	1	nvd	53	1	nvd	53	1	nvd
54	1	nvd	54	1	nvd	54	1	nvd	54	1	nvd	54	1	nvd	54	1	nvd
55	1	nvd	55	1	nvd	55	1	nvd	55	1	nvd	55	1	nvd	55	2	nvd
56	1	nvd	56	1	nvd	56	1	nvd	56	1	nvd	56	1	nvd	56	2	nvd
57	1	nvd	57	1	nvd	57	1	nvd	57	1	nvd	57	1	nvd	57	2	nvd
58	1	nvd	58	1	nvd	58	1	nvd	58	1	nvd	58	1	nvd	58	2	nvd
59	1	nvd	59	1	nvd	59	1	nvd	59	1	nvd	59	1	nvd	59	2	nvd
60	1	nvd	60	1	nvd	60	1	nvd	60	1	nvd	60	1	nvd	60	2	nvd
Total	60 fish	0/60	Total	60 fish	0/60	Total	60 fish	0/60	Total	60 fish	0/60	Total	60 fish	0/60	Total	66 fish	0/66

* no virus detected

Table 5. Results of pathogen survey of sockeye emergent fry

Collection Site- Okanagan River Collection Date-March 25, 2001 Sample-60 sockeye emergent fry Assay Date-March 28, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-April 4, 2001 Sample-60 sockeye emergent fry Assay Date-April 6, 2001 (samples not frozen) Cell lines-EPC and CHSE-214	Collection Site- Okanagan River Collection Date-April 16, 2001 Sample-60 sockeye emergent fry Assay Date-April 18, 2001 (samples not frozen) Cell lines-EPC and CHSE
---	---	---

Pool Number	Number of fish/pool	Virology Results	Pool Number	Number of fish/pool	Virology Results	Pool Number	Number of fish/pool	Virology Results
1	1	*nvd	1	1	*nvd	1	1	*nvd
2	1	nvd	2	1	nvd	2	1	nvd
3	1	nvd	3	1	nvd	3	1	nvd
4	1	nvd	4	1	nvd	4	1	nvd
5	1	nvd	5	1	nvd	5	1	nvd
6	1	nvd	6	1	nvd	6	1	nvd
7	1	nvd	7	1	nvd	7	1	nvd
8	1	nvd	8	1	nvd	8	1	nvd
9	1	nvd	9	1	nvd	9	1	nvd
10	1	nvd	10	1	nvd	10	1	nvd
11	1	nvd	11	1	nvd	11	1	nvd
12	1	nvd	12	1	nvd	12	1	nvd
13	1	nvd	13	1	nvd	13	1	nvd
14	1	nvd	14	1	nvd	14	1	nvd
15	1	nvd	15	1	nvd	15	1	nvd
16	1	nvd	16	1	nvd	16	1	nvd
17	1	nvd	17	1	nvd	17	1	nvd
18	1	nvd	18	1	nvd	18	1	nvd
19	1	nvd	19	1	nvd	19	1	nvd
20	1	nvd	20	1	nvd	20	1	nvd
21	1	nvd	21	1	nvd	21	1	nvd
22	1	nvd	22	1	nvd	22	1	nvd
23	1	nvd	23	1	nvd	23	1	nvd
24	1	nvd	24	1	nvd	24	1	nvd
25	1	nvd	25	1	nvd	25	1	nvd
26	1	nvd	26	1	nvd	26	1	nvd
27	1	nvd	27	1	nvd	27	1	nvd
28	1	nvd	28	1	nvd	28	1	nvd
29	1	nvd	29	1	nvd	29	1	nvd
30	1	nvd	30	1	nvd	30	1	nvd
			31	1	nvd	31	1	nvd
Total	30 fish	0/30	32	1	nvd	32	1	nvd
			33	1	nvd	33	1	nvd
			34	1	nvd	34	1	nvd
			35	1	nvd	35	1	nvd
			36	1	nvd	36	1	nvd
			37	1	nvd	37	1	nvd
			38	1	nvd	38	1	nvd
			39	1	nvd	39	1	nvd
			40	1	nvd	40	1	nvd
			41	1	nvd	41	1	nvd
			42	1	nvd	42	1	nvd
			43	1	nvd	43	1	nvd
			44	1	nvd	44	1	nvd
			45	1	nvd	45	1	nvd
			46	1	nvd	46	1	nvd
			47	1	nvd	47	1	nvd
			48	1	nvd	48	1	nvd
			49	1	nvd	49	1	nvd
			50	1	nvd	50	1	nvd
			51	1	nvd	51	1	nvd
			52	1	nvd	52	1	nvd
			53	1	nvd	53	1	nvd
			54	1	nvd	54	1	nvd
			55	1	nvd	55	1	nvd
			56	1	nvd	56	2	nvd
			57	1	nvd	57	2	nvd
			58	1	nvd	58	2	nvd
			59	1	nvd	59	2	nvd
			60	1	nvd	60	2	nvd
			Total	60 fish	0/60	Total	65 fish	0/65

*nvd-no virus detected

Table 6. Results of pathogen survey of sockeye fry

Collection Site- Okanagan Rv Collection Date-June 11, 2001 Sample-60 sockeye fry Assay Date-June 13, 2001 (samples not frozen)	Collection Site- Okanagan Rv Collection Date-June 12, 2001 Sample-60 sockeye fry Assay Date-June 14, 2001 (samples not frozen)	Collection Site- Okanagan River Collection Date-June 13, 2001 Sample-60 sockeye fry Assay Date-June 15, 2001 (samples not frozen)	Collection Site- Osoyoss Lake Collection Date-November 28, 2001 Sample-60 sockeye fry Assay Date-November 29, 2001 (samples not frozen)
Cell lines-EPC and CHSE	Cell lines-EPC and CHSE	Cell lines-EPC and CHSE	Cell lines-EPC and CHSE

Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results	Pool No.	Number of fish/pool	Virology Results
1	1	*nvd	1	1	*nvd	1	1	*nvd	1	2	*nvd
2	1	nvd	2	1	nvd	2	1	nvd	2	2	nvd
3	1	nvd	3	1	nvd	3	1	nvd	3	2	nvd
4	1	nvd	4	1	nvd	4	1	nvd	4	2	nvd
5	1	nvd	5	1	nvd	5	1	nvd	5	2	nvd
6	1	nvd	6	1	nvd	6	1	nvd	6	2	nvd
7	1	nvd	7	1	nvd	7	1	nvd	7	2	nvd
8	1	nvd	8	1	nvd	8	1	nvd	8	2	nvd
9	1	nvd	9	1	nvd	9	1	nvd	9	2	nvd
10	1	nvd	10	1	nvd	10	1	nvd	10	2	nvd
11	1	nvd	11	1	nvd	11	1	nvd	11	2	nvd
12	1	nvd	12	1	nvd	12	1	nvd	12	2	nvd
13	1	nvd	13	1	nvd	13	1	nvd	13	2	nvd
14	1	nvd	14	1	nvd	14	1	nvd	14	2	nvd
15	1	nvd	15	1	nvd	15	1	nvd	15	2	nvd
16	1	nvd	16	1	nvd	16	1	nvd	16	2	nvd
17	1	nvd	17	1	nvd	17	1	nvd	17	2	nvd
18	1	nvd	18	1	nvd	18	1	nvd	18	2	nvd
19	1	nvd	19	1	nvd	19	1	nvd	19	2	nvd
20	1	nvd	20	1	nvd	20	1	nvd	20	2	nvd
21	1	nvd	21	1	nvd	21	1	nvd	21	2	nvd
22	1	nvd	22	1	nvd	22	1	nvd	22	2	nvd
23	1	nvd	23	1	nvd	23	1	nvd	23	2	nvd
24	1	nvd	24	1	nvd	24	1	nvd	24	2	nvd
25	1	nvd	25	1	nvd	25	1	nvd	25	2	nvd
26	1	nvd	26	1	nvd	26	1	nvd	26	2	nvd
27	1	nvd	27	1	nvd	27	1	nvd	27	2	nvd
28	1	nvd	28	1	nvd	28	1	nvd	28	2	nvd
29	1	nvd	29	1	nvd	29	1	nvd	29	2	nvd
30	1	nvd	30	1	nvd	30	1	nvd	30	2	nvd
31	1	nvd	31	1	nvd	31	1	nvd	Total 60 fish 0/60		
32	1	nvd	32	1	nvd	32	1	nvd			
33	1	nvd	33	1	nvd	33	1	nvd			
34	1	nvd	34	1	nvd	34	1	nvd			
35	1	nvd	35	1	nvd	35	1	nvd			
36	1	nvd	36	1	nvd	36	1	nvd			
37	1	nvd	37	1	nvd	37	1	nvd			
38	1	nvd	38	1	nvd	38	1	nvd			
39	1	nvd	39	1	nvd	39	1	nvd			
40	1	nvd	40	1	nvd	40	1	nvd			
41	1	nvd	41	1	nvd	41	1	nvd			
42	1	nvd	42	1	nvd	42	1	nvd			
43	1	nvd	43	1	nvd	43	1	nvd			
44	1	nvd	44	1	nvd	44	1	nvd			
45	1	nvd	45	1	nvd	45	1	nvd			
46	1	nvd	46	1	nvd	46	1	nvd			
47	1	nvd	47	1	nvd	47	1	nvd			
48	1	nvd	48	1	nvd	48	1	nvd			
49	1	nvd	49	1	nvd	49	1	nvd			
50	1	nvd	50	1	nvd	50	1	nvd			
51	1	nvd	51	1	nvd	51	1	nvd			
52	1	nvd	52	1	nvd	52	1	nvd			
53	1	nvd	53	1	nvd	53	1	nvd			
54	1	nvd	54	1	nvd	54	1	nvd			
55	1	nvd	55	1	nvd	55	1	nvd			
56	1	nvd	56	1	nvd	56	1	nvd			
57	1	nvd	57	1	nvd	57	1	nvd			
58	1	nvd	58	1	nvd	58	1	nvd			
59	1	nvd	59	1	nvd	59	1	nvd			
60	1	nvd	60	1	nvd	60	1	nvd			
Total	60 fish	0/60	Total	60 fish	0/60	Total	60 fish	0/60			

*nvd=no virus detected

Table 7. Results of pathogen survey of sockeye adults post-spawners

Collection Site- Okanagan River

Collection Date-October 16, 2001

Sample 183 sockeye adults post-spawners

Assay Date-October 30-November 7, 2001 (samples frozen)

Cell lines-EPC and CHSE

Virology Fish Number	Number of fish/pool	Sex	Virology Results pfu/ml		Blood Smear	<i>Myxobolus cerebralis</i>	<i>Ceratomyxa shasta</i>	Virus Isolate tested by IFAT
			Reprod FI	Kidney				
1	1	F	10 ⁻⁴	nvd	no sample	neg	no sample	
2	1	F	10 ⁻²	nvd	no sample	neg	no sample	
3	1	F	10 ⁻³	nvd	no sample	neg	no sample	
4	1	F	10 ⁻⁴	10 ⁻⁶	no sample	neg	no sample	
5	1	F	*nvd	nvd	no sample	neg	no sample	
6	1	F	nvd	nvd	no sample	neg	no sample	
7	1	F	nvd	nvd	no sample	neg	no sample	
8	1	F	nvd	nvd	no sample	neg	no sample	
9	1	F	nvd	nvd	no sample	neg	no sample	
10	1	F	nvd	nvd	no sample	neg	no sample	
11	1	M	nvd	nvd	no sample	neg	no sample	
12	1	M	nvd	nvd	no sample	neg	no sample	
13	1	M	nvd	nvd	no sample	neg	no sample	
14	1	M	nvd	nvd	no sample	neg	no sample	
15	1	M	nvd	nvd	no sample	neg	no sample	
16	1	M	nvd	10 ⁻³	no sample	neg	no sample	
17	1	M	nvd	nvd	no sample	neg	no sample	
18	1	M	nvd	nvd	no sample	neg	no sample	
19	1	F	10 ⁻⁵	10 ⁻²	negative	neg	no sample	
20	1	F	nvd	nvd	negative	neg	no sample	
21	1	F	nvd	nvd	no sample	neg	negative	
22	1	F	nvd	nvd	negative	neg	negative	
23	1	F	nvd	nvd	no sample	neg	negative	
24	1	F	nvd	nvd	negative	neg	negative	
25	1	F	nvd	nvd	negative	neg	negative	
26	1	F	nvd	nvd	negative	neg	negative	
27	1	F	nvd	nvd	negative	neg	negative	
28	1	F	nvd	10 ⁻⁴	negative	neg	negative	
29	1	M	nvd	nvd	negative	neg	negative	
30	1	M	10 ⁻³	10 ⁻⁴	no sample	neg	negative	IFAT
31	1	M	nvd	nvd	negative	neg	negative	
32	1	M	nvd	nvd	no sample	neg	negative	
33	1	M	nvd	nvd	negative	neg	negative	
34	1	M	nvd	10 ⁻²	no sample	neg	negative	IFAT
35	1	M	nvd	nvd	no sample	neg	negative	
36	1	M	nvd	nvd	no sample	neg	negative	
37	1	M	nvd	nvd	no sample	neg	negative	
38	1	M	nvd	nvd	no sample	neg	negative	
39	1	M	nvd	nvd	no sample	neg	negative	
40	1	M	nvd	10 ⁻⁵	no sample	neg	negative	
41	1	F	nvd	nvd	no sample	neg	negative	
42	1	F	nvd	nvd	negative	neg	negative	
43	1	F	nvd	nvd	no sample	neg	negative	
44	1	F	10 ⁻⁴	10 ⁻⁵	no sample	neg	negative	
45	1	F	nvd	nvd	negative	neg	negative	
46	1	F	nvd	nvd	no sample	neg	negative	
47	1	M	nvd	nvd	negative	neg	negative	
48	1	M	nvd	nvd	no sample	neg	negative	
49	1	M	nvd	nvd	no sample	neg	negative	
50	1	M	nvd	nvd	no sample	neg	negative	
51	1	M	nvd	nvd	no sample	neg	negative	
52	1	M	nvd	nvd	no sample	neg	negative	

Virology Fish Number	Number of fish/pool	Sex	Virology Results pfu/ml		Blood Smear	<i>Myxobolus cerebralis</i>	<i>Ceratomyxa shasta</i>	Virus Isolate tested by IFAT
Reprod FI	Kidney							
53	1	M	nvd	nvd	no sample	neg	negative	
54	1	M	nvd	nvd	no sample	neg	negative	
55	1	M	nvd	nvd	no sample	neg	negative	
56	1	M	nvd	nvd	negative	neg	negative	
57	1	M	nvd	10 ⁶	negative	neg	negative	
58	1	M	nvd	10 ²	negative	neg	negative	
59	1	M	nvd	nvd	negative	neg	negative	
60	1	M	nvd	10 ²	negative	neg	negative	
61	1	M	10 ²	nvd	negative	neg	negative	
62	1	M	10 ²	nvd	negative	neg	negative	
63	1	M	10 ²	nvd	negative	neg	negative	
64	1	M	10 ⁵	10 ⁵	negative	neg	negative	IFAT
65	1	M	nvd	nvd	negative	neg	negative	
66	1	F	nvd	nvd	negative	neg	negative	
67	1	F	nvd	10 ²	negative	neg	negative	IFAT
68	1	F	nvd	nvd	negative	neg	negative	
69	1	F	nvd	nvd	negative	neg	negative	
70	1	F	nvd	nvd	negative	neg	negative	
71	1	F	nvd	nvd	negative	neg	negative	
72	1	F	nvd	nvd	negative	neg	negative	
73	1	F	nvd	nvd	no sample	neg	negative	
74	1	F	nvd	10 ²	no sample	neg	negative	
75	1	F	10 ³	10 ³	no sample	neg	negative	
76	1	F	nvd	10 ⁴	no sample	neg	negative	
77	1	M	nvd	nvd	no sample	neg	negative	
78	1	M	nvd	10 ²	no sample	neg	negative	
79	1	M	nvd	nvd	no sample	neg	negative	
80	1	M	nvd	10 ⁴	no sample	neg	negative	IFAT
81	1	M	nvd	nvd	no sample	neg	negative	
82	1	M	nvd	nvd	no sample	neg	negative	
83	1	M	nvd	nvd	no sample	neg	negative	
84	1	M	nvd	nvd	no sample	neg	negative	
85	1	M	nvd	10 ⁴	no sample	neg	negative	IFAT
86	1	M	nvd	nvd	no sample	neg	negative	
87	1	M	nvd	nvd	no sample	neg	negative	
88	1	M	nvd	nvd	no sample	neg	negative	
89	1	M	nvd	nvd	no sample	neg	negative	
90	1	M	nvd	10 ²	no sample	neg	negative	
91	1	M	nvd	nvd	no sample	neg	negative	
92	1	M	nvd	nvd	no sample	neg	negative	
93	1	F	nvd	nvd	no sample	neg	negative	
94	1	F	nvd	nvd	no sample	neg	negative	
95	1	F	nvd	nvd	no sample	neg	negative	
96	1	M	nvd	nvd	no sample	neg	negative	
97	1	M	nvd	10 ³	no sample	neg	negative	IFAT
98	1	M	nvd	nvd	no sample	neg	negative	
99	1	M	nvd	nvd	no sample	neg	negative	
100	1	M	nvd	nvd	no sample	neg	negative	
101	1	M	nvd	nvd	no sample	neg	negative	
102	1	M	nvd	nvd	no sample	neg	negative	
103	1	M	nvd	nvd	no sample	neg	negative	
104	1	M	nvd	nvd	no sample	neg	negative	
105	1	M	nvd	10 ²	no sample	neg	negative	
106	1	M	nvd	nvd	no sample	neg	negative	
107	1	M	nvd	10 ⁴	no sample	neg	negative	IFAT
108	1	F	nvd	nvd	no sample	neg	negative	
109	1	F	nvd	nvd	negative	neg	negative	
110	1	F	10 ³	nvd	negative	neg	negative	
111	1	F	10 ⁴	nvd	negative	neg	negative	
112	1	F	10 ³	nvd	negative	neg	negative	
113	1	F	nvd	nvd	negative	neg	negative	
114	1	F	10 ⁴	10 ³	negative	neg	negative	IFAT

Virology Fish Number	Number of fish/pool	Sex	Virology Results pfu/ml		Blood Smear	<i>Myxobolus cerebralis</i>	<i>Ceratomyxa shasta</i>	Virus Isolate tested by IFAT
Reprod FI	Kidney							
115	1	F	10 ⁻²	nvd	no sample	neg	negative	
116	1	F	10 ⁻³	nvd	no sample	neg	negative	
117	1	M	nvd	nvd	no sample	neg	negative	
118	1	M	nvd	nvd	no sample	neg	negative	
119	1	M	nvd	nvd	negative	neg	negative	
120	1	M	nvd	10 ⁻⁶	negative	neg	negative	IFAT
121	1	M	nvd	10 ⁻⁴	negative	neg	negative	IFAT
122	1	M	nvd	10 ⁻⁵	negative	neg	negative	IFAT
123	1	M	nvd	nvd	negative	neg	negative	
124	1	M	nvd	10 ⁻²	negative	neg	negative	
125	1	M	nvd	nvd	negative	neg	negative	
126	1	M	10 ⁻⁴	10 ⁻⁴	negative	neg	negative	IFAT
127	1	M	nvd	nvd	negative	neg	negative	
128	1	M	nvd	nvd	negative	neg	negative	
129	1	M	nvd	nvd	negative	neg	negative	
130	1	M	nvd	10 ⁻³	negative	neg	negative	IFAT
131	1	M	nvd	nvd	no sample	neg	negative	
132	1	F	10 ⁻⁵	10 ⁻³	no sample	neg	negative	IFAT
133	1	F	10 ⁻⁶	10 ⁻⁶	no sample	neg	negative	IFAT
134	1	M	10 ⁻⁶	10 ⁻⁵	no sample	neg	negative	IFAT
135	1	F	nvd	10 ⁻²	no sample	neg	negative	
136	1	F	10 ⁻⁵	10 ⁻⁴	no sample	neg	negative	IFAT
137	1	F	nvd	nvd	no sample	neg	negative	
138	1	F	10 ⁻³	nvd	no sample	neg	negative	
139	1	F	10 ⁻²	nvd	no sample	neg	negative	
140	1	F	10 ⁻⁴	nvd	no sample	neg	negative	
141	1	F	10 ⁻³	10 ⁻²	no sample	neg	negative	
142	1	F	10 ⁻²	nvd	no sample	neg	negative	
143	1	F	nvd	nvd	no sample	neg	negative	
144	1	M	nvd	nvd	no sample	neg	negative	
145	1	M	nvd	10 ⁻⁵	no sample	neg	negative	IFAT
146	1	M	nvd	nvd	no sample	neg	negative	
147	1	M	nvd	nvd	no sample	neg	negative	
148	1	M	nvd	nvd	no sample	neg	negative	
149	1	M	nvd	10 ⁻⁴	no sample	neg	negative	IFAT
150	1	M	nvd	nvd	no sample	neg	negative	
151	1	M	nvd	nvd	no sample	neg	negative	
152	1	M	nvd	nvd	no sample	neg	negative	
153	1	M	nvd	nvd	no sample	neg	negative	
154	1	F	10 ⁻³	nvd	no sample	neg	negative	
155	1	F	nvd	10 ⁻²	no sample	neg	negative	
156	1	F	nvd	nvd	no sample	neg	negative	
157	1	M	nvd	nvd	no sample	neg	negative	
158	1	M	nvd	nvd	no sample	neg	negative	
159	1	M	nvd	nvd	no sample	neg	negative	
160	1	M	nvd	nvd	no sample	neg	negative	
161	1	M	nvd	nvd	no sample	neg	negative	
162	1	F	nvd	nvd	no sample	neg	negative	
163	1	F	10 ⁻²	nvd	no sample	neg	negative	
164	1	F	nvd	nvd	no sample	neg	negative	
165	1	F	nvd	nvd	no sample	neg	negative	
166	1	F	nvd	nvd	no sample	neg	negative	
167	1	F	nvd	nvd	no sample	neg	negative	
168	1	F	nvd	nvd	no sample	neg	negative	
169	1	F	nvd	nvd	no sample	neg	negative	
170	1	M	nvd	10 ⁻⁴	no sample	neg	negative	IFAT
171	1	M	nvd	10 ⁻⁵	no sample	neg	negative	IFAT
172	1	M	nvd	nvd	no sample	neg	negative	
173	1	M	nvd	10 ⁻⁵	no sample	neg	negative	IFAT
174	1	F	nvd	10 ⁻⁶	no sample	neg	negative	IFAT
175	1	F	10 ⁻⁴	nvd	no sample	neg	negative	

Virology Fish Number	Number of fish/pool	Sex	Virology Results pfu/ml		Blood Smear	<i>Myxobolus cerebralis</i>	<i>Ceratomyxa shasta</i>	Virus Isolate tested by IFAT
			Reprod FI	Kidney				
176	1	F	10 ⁻²	nvd	no sample	neg	negative	
177	1	F	nvd	nvd	no sample	neg	negative	
178	1	M	nvd	nvd	no sample	neg	negative	
179	1	M	nvd	nvd	no sample	neg	negative	
180	1	M	nvd	nvd	no sample	neg	negative	
181	1	M	nvd	nvd	no sample	neg	negative	
182	1	M	nvd	nvd	no sample	neg	negative	
183	1	M	nvd	nvd	no sample	neg	negative	

Total	32/183	43/183	0/49	0/183	0/163	24 IFAT
Prevalence	17.5%	23.5%	0%	0%	0%	

*nvd-no virus detected

APPENDIX C

Whirling disease exposure
Daily temperature data and
Site photos

Whirling disease live box exposure
Daily temperatures (May 2001)

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Date	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)
11-May	20.68	19.36	14.82	10.39	18.39	20.30	12.97	12.17
12-May	19.81	18.78	13.25	11.48	17.05	18.81	13.27	12.31
13-May	20.51	19.34	13.53	11.02	17.50	19.43	13.83	12.83
14-May	18.50	17.66	12.17	9.93	16.63	17.00	11.78	11.43
15-May	17.71	16.75	11.84	10.01	15.50	16.89	10.72	9.73
16-May	18.15	17.05	12.29	10.32	15.68	17.23	13.08	10.38
17-May	16.96	15.64	11.71	9.81	15.19	15.44	12.49	10.79
18-May	17.59	16.00	12.64	10.37	14.35	15.11	14.14	11.45
19-May	18.64	17.78	14.09	10.70	15.58	16.84	15.81	12.36
20-May	18.38	17.18	13.88	10.63	15.51	16.57	16.77	12.94
21-May	20.02	18.07	14.64	10.71	16.37	18.04	17.70	13.53
22-May	22.47	19.95	15.60	11.04	18.03	20.64	14.61	12.82
23-May	23.73	24.43	19.44	22.54	23.44	23.90	19.35	20.03
Averages	19.47	18.31	13.84	11.46	16.86	18.17	14.35	12.52

Whirling disease live box exposure
Daily temperatures (October 2001)

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Date	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)	Daily Ave (*C)
5-Oct-01	22.55	22.60	22.55	22.79	22.72	22.81	22.64	22.77
6-Oct-01	20.50	20.49	20.43	20.54	20.44	20.67	20.53	20.63
7-Oct-01	19.02	19.01	18.93	19.09	18.96	19.21	19.05	19.17
8-Oct-01	19.29	19.29	19.22	19.34	19.27	19.47	19.34	19.44
9-Oct-01	14.37	14.51	16.46	14.05	14.73	15.13	16.66	16.62
10-Oct-01	8.85	9.57	12.06	10.31	10.16	9.58	13.14	13.21
11-Oct-01	9.00	9.95	12.30	10.51	10.25	10.35	12.20	12.02
12-Oct-01	9.04	9.90	11.92	10.51	10.18	9.98	12.71	12.83
13-Oct-01	8.17	9.74	11.87	9.60	9.48	9.63	12.72	12.75
14-Oct-01	9.14	10.26	11.90	10.13	10.54	10.66	12.45	12.44
15-Oct-01	7.59	9.53	11.18	9.96	9.69	9.62	11.98	12.03
16-Oct-01	8.88	10.02	11.35	10.06	9.71	9.63	11.94	12.00
17-Oct-01	8.95	10.26	11.03	9.25	9.59	9.35	11.60	11.76
18-Oct-01	7.68	9.74	10.38	8.66	8.61	8.31	11.09	11.32
19-Oct-01	7.81	9.51	10.67	9.34	8.68	8.65	11.58	11.47
20-Oct-01	7.29	9.24	10.42	9.21	9.21	9.15	11.53	11.53
21-Oct-01	7.69	9.42	10.35	9.46	9.06	8.80	11.31	11.37
22-Oct-01	8.03	9.64	10.10	9.35	8.80	8.60	10.95	11.05
23-Oct-01	7.16	9.44	9.69	9.46	8.29	7.97	10.32	10.61
24-Oct-01	6.78	9.04	9.41	9.07	8.08	7.78	10.24	10.24
25-Oct-01	7.75	9.37	9.57	9.29	8.48	8.18	10.23	10.19
26-Oct-01	8.98	9.96	9.63	9.50	8.74	8.59	10.21	10.16
27-Oct-01	8.03	9.99	9.44	9.25	8.84	8.65	9.84	10.00
28-Oct-01	5.77	8.96	8.61	8.83	7.82	7.41	9.09	9.36
29-Oct-01	4.84	8.61	8.66	9.22	8.71	7.94	10.19	10.50
Averages	10.13	11.52	12.33	11.47	11.16	11.04	12.94	13.02

Photos of the exposure sites located in Figure 3.



Photo 9. Whirling disease Site 2 taken May 11, 2001



Photo 10. Whirling disease Site 4 taken May 11, 2001



Photo 11. Whirling disease Site 5 taken May 11, 2001



Photo 12. Whirling disease Site 7 taken May 11, 2001

APPENDIX D

Age – Length data
2000 and 2001

	Largemouth Bass			Smallmouth Bass			Sucker, general **		
Age (years)	Length (mm)	Fish sampled 2000	Fish sampled 2001	Length (mm)	Fish sampled 2000	Fish sampled 2001	Length (mm)	Fish sampled 2000	Fish sampled 2001
0	assumed<73	24	10	assumed <76	28	19			
1	102	22	30	140	26	21	46	0	0
2	203	3	10	178	18	21	76	0	0
3	254	1	1	211	18	14	124	1	4
4	305	2	0	246	19	16	170	1	21
5	343	0	0	274	4	11	190	0	5
6	368	0	0	305	9	3	229	0	23
7	419	0	0	330	2	5	284	0	20
8	432	0	0	351	1	5	305	4	4
9	445	0	0	368	0	1	340	2	7
10	457	0	0	391	0	0	356	1	10
11	483	0	0	396	0	0	376	6	21
12	503	0	0	411	1	0	assumed 401	0	15
13	518	0	0	414	0	0	assumed > 401mm	4	30
14	533	0	0	435*	1	2			
Totals	LMB	52	51	SMB	127	118	SU	19	160

* SMB: assumed to be between 441mm (13 years) and 457mm (15 years), information not available

** Sucker, general was based on largescale sucker information

Source: Scott, W.B. and E.J. Crossman. 1973. *Freshwater Fishes of Canada*, bulletin 184. Fisheries Research Board of Canada. Ottawa: Canadian Government Publishing Centre

	Northern Pike min now			Pumpkinseed			Yellow perch		
Age (years)	Length (mm)	Fish sampled 2000	Fish sampled 2001	Length (mm)	Fish sampled 2000	Fish sampled 2001	Length (mm)	Fish sampled 2000	Fish sampled 2001
0							48	0	0
1	48	4	0	74	7	10	71	18	20
2	99	6	12	104	19	29	86	14	14
3	147	2	11	124	4	11	124	14	10
4	198	9	13	145	2	4	142	16	24
5	226	7	7	157	1	1	170	28	37
6	274	13	8	173	2	1	213	15	11
7	302	11	4	185	0	1	231	0	0
8	345	9	10	198	0	0	259	1	1
9	366	2	4				302	0	2
10	386	6	2						
11	411	3	4						
12	assumed >490mm	4	5						
13									
14									
Totals	NSC	76	80	PMB	35	57	YP	106	119

APPENDIX E

Findings from year 2001
pathogen survey

Table I. Findings from year 2001 pathogen surveys*

Below McIntyre Dam

	<u>No. Collected</u>	<u>IHNV</u>	<u>IPNV</u>	<u>EIBSV</u>	<u>MC</u>	<u>CS</u>
<u>Salmonids</u>						
Sockeye (juveniles)	761	0/761	0/761	NT	NT	NT
Sockeye (spawners)	183	62/183	0/183	0/49	0/183	0/163
Whitefish (various ages)	40	0/40	0/40	1/40	NT	?
Total salmonids	984					
<u>Non-salmonids</u>						
Eight species/groups	371	0/371	0/371	15/366	NT	NT
Total non-salmonids	371					

*IHNV = infectious haematopoietic necrosis virus; IPNV = infectious pancreatic necrosis virus; EIBSV = erythrocytic inclusion body syndrome virus; ? = awaiting results; NT = not tested (fish too small to test or tests not required); fractions = no. fish positive for indicated pathogen/no. fish tested; IHNV was likely IHNV, type 1; positive EIBSV test = > 2 inclusions seen per test

Table II. Findings from year 2001 pathogen surveys*

Above McIntyre Dam

	<u>No. collected</u>	<u>IHNV</u>	<u>IPNV</u>	<u>EIBSV</u>	<u>MC</u>	<u>CS</u>
<u>Salmonids</u>						
Kokanee (juveniles)	150	0/150	0/150	NT	NT	?
Kokanee (spawners)	150	103/150	0/150	0/149	NT	?
Whitefish (various ages)	61	0/61	0/61	0/50	NT	?
Total salmonids	361					
<u>Non-salmonids</u>						
Ten species/groups	386	0/386	0/386	20/374	NT	NT
Total non-salmonids	386					

*IHNV = infectious haematopoietic necrosis virus; IPNV = infectious pancreatic necrosis virus; EIBSV = erythrocytic inclusion body syndrome virus; ? = awaiting results; NT = not tested (fish too small to test or tests not required); fractions = no. fish positive for indicated pathogen/no. fish tested; IHNV was likely IHNV, type 1; positive EIBSV test = > 2 inclusions seen per test

Table III. Pathogen findings for non-salmonids, year 2001*

Below McIntyre Dam

<u>Species/Group</u>	<u>No. Collected</u>	<u>IHNV</u>	<u>IPNV</u>	<u>EIBSV</u>	<u>MC</u>	<u>CS</u>
Black crappie	20	0/20	0/20	2/20	NT	NT
Chiselmouth	3	0/3	0/3	0/3	NT	NT
Northern pike minnow	27	0/27	0/27	2/27	NT	NT
Largemouth bass	51	0/51	0/51	2/51	NT	NT
Pumpkinseed	37	0/37	0/37	0/37	NT	NT
Smallmouth bass	37	0/37	0/37	5/37	NT	NT
Sucker spp.	81	0/81	0/81	4/80	NT	NT
Yellow perch	115	0/115	0/115	0/111	NT	NT
Total non-salmonids			371			

*IHNV = infectious haematopoietic necrosis virus; IPNV = infectious pancreatic necrosis virus; EIBSV = erythrocytic inclusion body syndrome virus; ? = awaiting results; NT = not tested (fish too small to test or tests not required); fractions = no. fish positive for indicated pathogen/no. fish tested; IHNV was likely IHNV, type 1; positive EIBSV test = > 2 inclusions seen per test

Table IV. Pathogen findings for non-salmonids, year 2001*

Above McIntyre Dam

<u>Species, Group</u>	<u>No. collected</u>	<u>IHNV</u>	<u>IPNV</u>	<u>EIBSV</u>	<u>MC</u>	<u>CS</u>
Chiselmouth	1	0/1	0/1	0/1	NT	NT
Chub(s)	6	0/6	0/6	0/6	NT	NT
Northern pike minnow	53	0/53	0/53	0/52	NT	NT
Peamouth chub	55	0/55	0/55	0/54	NT	NT
Pumpkinseed	21	0/21	0/21	3/21	NT	NT
Prickly sculpin	32	0/32	0/32	0/31	NT	NT
Redside shiner	54	0/54	0/54	0/47	NT	NT
Smallmouth bass	82	0/82	0/82	13/82	NT	NT
Sucker(s)	78	0/78	0/78	4/76	NT	NT
Yellow perch	4	0/4	0/4	0/4	NT	NT
Total non-salmonids	386					

*IHNV = infectious haematopoietic necrosis virus; IPNV = infectious pancreatic necrosis virus; EIBSV = erythrocytic inclusion body syndrome virus; ? = awaiting results; NT = not tested (fish too small to test or tests not required); fractions = no. fish positive for indicated pathogen/no. fish tested; IHNV was likely IHNV, type 1; positive EIBSV test = > 2 inclusions seen per test

Table V. Non-salmonids collected **above McIntyre Dam** to date

<u>Species/Group</u>	<u>Year 2000</u>	<u>Year 2001</u>
Black bullhead (catfish)	2	0
Burbot	1	0
Common Carp	1	0
Chiselmouth	0	1
Chub spp.	0	6
Lake chub	1	0
Northern pike minnow	68	53
Peamouth chub	71	55
Pumpkinseed sunfish	12	21
Prickly sculpin	0	32
Sculpin spp.	40	0
Redside shiner	28	54
Smallmouth bass	89	82
Sucker spp.	72	78
Yellow perch	6	5

Table VI. Non-salmonids collected **below McIntyre Dam** to date

<u>Species/ Group</u>	<u>Year 2000</u>	<u>Year 2001</u>
Black bullhead (catfish)	1	0
Black crappie	1	20
Common Carp	4	0
Chiselmouth	0	3
Largemouth bass	52	51
Northern pike minnow	8	27
Pumpkinseed	24	37
Sculpin spp.	22	0
Smallmouth bass	39	37
Sucker spp.	39	81
Yellow perch	99	115

Table VII. Non-salmonids collected above and below McIntyre Dam

<u>Species/Group</u>	<u>Years 00 & 01 Above Dam</u>	<u>Years 00 & 01 Below Dam</u>
Black bullhead (catfish)	2	1
Black crappie	0	21
Burbot*	1	0
Common Carp	1	4
Chiselmouth*	1	3
Chub spp.*	6	0
Lake chub*	1	0
Largemouth bass	0	103
Northern pike minnow*	121	35
Peamouth chub*	126	0
Pumpkinseed sunfish	33	61
Prickly sculpin*	32	0
Sculpin spp.*	40	22
Redside shiner*	82	0
Smallmouth bass*	171	76
Sucker(s)*	150	120
Yellow perch*	10	214
Total species/groups	15	11
Total individuals	777	660
Desired sample size	720	720
*% fish migratory	95.4	70.1

*Based on reported ability to live in streams or to migrate into streams to spawn (Scott and Crossman 1973)

Table VIII. Salmonids collected above and below McIntyre Dam

<u>Species/Group</u>	<u>Years 00 & 01 Above Dam</u>	<u>Years 00 & 01 Below Dam</u>
Sockeye (juveniles)	0	969
Sockeye (adults)	0	391
Kokanee (juveniles)	330	0
Kokanee (adults)	365	0
Whitefish (various ages)	111	71
Total species/groups	3	3
Total individuals	806	1431

APPENDIX F

Specialists Resume
Trevor Evelyn

Trevor Evelyn

Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, B.C.

Dr. Trevor Evelyn retired from his position as head of the Fish Health and Parasitology Section at the Department of Fisheries and Oceans' Pacific Biological Station (PBS) in Nanaimo in 1997 after an active 32-year career of research in the fish health field. Dr. Evelyn's extensive studies on fish disease control have been widely published in leading fish health journals, and his expertise in his field is well recognized both nationally and internationally. Canada's Fish Health Protection Regulations are to a large extent a product of his and his colleagues' efforts. He is often an invited speaker at various national and international conferences and symposia, and over the years has served universities in Canada and abroad in a number of capacities, particularly by developing and supervising graduate student research projects. He has also served on the editorial boards of various science journals (currently two) and for 10 years was Editor re Microbial Fish Diseases for a leading fish health science journal. At the request of various national and international organizations, Dr. Evelyn has undertaken projects in many parts of the world including Iceland, various European countries, New Zealand, China, and several countries in Southeast Asia. In North America, he served the Fish Health Section of the American Fisheries Society in a number of capacities, including elected President. His work has earned him various honours, including the prestigious SF Snieszko Distinguished Service Award and an Honorary Doctor of Letters degree from Malaspina University College. In his retirement, Dr. Evelyn has remained active. His advice is constantly sought after by individuals and agencies with fish health-related problems, by the editors of a number of science journals, by book publishers, by various Canadian and foreign science funding agencies, and by the Canadian Experts Services Organization. Currently, Dr. Evelyn enjoys the post-retirement office facilities at the Pacific Biological Station and has been accorded the title of Scientist Emeritus.

FINAL

Evaluation of Experimental Re- introduction of Sockeye Salmon into Skaha Lake

OBJECTIVE 2 Exotic Fish Risk Assessment

YEAR 2 of 3

Submitted to:
Colville Confederated Tribes

Prepared by:
Karilyn Long
Okanagan Nation
Fisheries Commission

April 2002

EXECUTIVE SUMMARY

This report arising from Objective 2 of the three-year study “Evaluation of an experimental re-introduction of sockeye salmon into Skaha Lake” is concerned with the possibility of certain undesirable exotic fish termed “exotic fishes of concern” gaining access to upstream areas, and eventually colonizing them to the detriment of native species. While a number of exotic species are already quite widely established in the drainage, some exist only below McIntyre Dam. These might extend their range upstream and colonize Vaseux as well as Skaha Lake if the dam was modified or removed in the reintroduction process.

To confirm the ranges of exotic fishes as indicated from a literature review and in a report and recommendations from YEAR 1 sampling, the Okanagan Nation Fisheries Commission (ONFC) used a variety of fish sampling techniques to capture specimens over a range of habitats within the study area from April to November 2001.

Field sampling was by angling, beach seining, boat based electrofishing, gillnetting, minnow trapping and trap netting. There were thought to be only five species of exotic fishes of concern, i.e. black bullhead, black crappie, largemouth bass, tench and walleye, until 2001 when a 6th species – bluegill sunfish, were captured by electrofishing in Osoyoos Lake.

Currently, black bullheads are in Skaha Lake; largemouth bass are in Vaseux Lake; but black crappie, bluegill and tench have not been found above Osoyoos Lake and walleye have not been found in the Okanagan River upriver of Mallot, Washington.

Range extensions would be heavily influenced by availability of suitable food and habitat. Black crappie range widely in open water and feed on a variety of very small fishes and plankton. Largemouth bass are predatory feeders in littoral areas and because smallmouth bass are widely distributed in the Okanagan basin and share some food preferences and behavioral similarities with largemouth they may reflect some of the hazards that the former could constitute for salmonids. Both bass species are piscivorous, but while smallmouth are known to feed on sockeye fry as they coexist in littoral areas during migrations to and from the lakes pelagic zone, largemouth lie in wait at the edge of the littoral zone as territorial ambush predators limiting their predation on pelagic salmonids. Tench are carp-like fish with likely some of the same impact on salmonids that carp have – notably competition for food. Walleye are predators known to travel long distances.

Some of the risks associated with range extension of exotic species of concern into Skaha Lake and other upstream waters were assembled in years 1 and 2 and are summarized in Table 3. Several recommendations for the final year of sampling should if followed closely ensure that there are no remaining gaps in data.

ACKNOWLEDGMENTS

The Okanagan Nation Fisheries Commission would like to acknowledge valuable contributions made by a number of people to Objective 2: Exotic Fish Species Risk Assessment (YEAR 2).

First we would like to pay special thanks again to Monte Miller and the Colville Confederated Tribes (CCT) for the use of their electrofishing boat. Thanks for taking time out of your busy schedule to come catch fish in Canada.

The gillnets and beach seines were loaned by Steve Matthews of the Ministry of Water, Land and Air Protection while Don Ignace and Darby Hewitt of the Skeetcheson Band lent us two of their trap nets and Tanji Tsamura of BC Fisheries who also lent us a trap net.

The ONFC's E-Team members lead by Fabian Alexis were a great help with field sampling and equipment maintenance. E-Team members include:

- Dion Alex
- Rodi Big Eagle
- Alexandra Butler
- Leigh Holt
- Charles Kruger
- Damon Lawrence
- Emory Parker
- Ian Parker
- Lori Snow.

Thanks to our quality control advisor, Chris Bull who never hesitated in joining us for field work on those sunny days and Howard Smith who tirelessly edited this report.

The YEAR 2 report could not have been completed without the accumulation of these resources and experts. Thanks again to everyone involved.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
ACKNOWLEDGMENTS	ii
TABLE OF CONTENTS.....	iii
LIST OF FIGURES, TABLES AND PHOTOGRAPHS	iv
1.0 INTRODUCTION	1
1.1 Project Background	1
1.2 Objective 2 Scope	1
1.3 Project Study Area	1
2.0 INVENTORY OF EXOTIC FISH SPECIES	3
2.1 Exotic fish inventory methods and results	3
2.1.1 Angling.....	4
2.1.2 Beach seining.....	5
2.1.3 Electrofishing.....	5
2.1.4 Gillnetting.....	6
2.1.5 Minnow trapping	6
2.1.6 Trap netting	7
2.2 Inventory summary.....	7
3.0 LITERATURE REVIEW OF THE HABITAT PREFERENCES OF AN ADDITIONAL EXOTIC FISHES OF CONCERN.....	15
4.0 AVAILABILITY OF SUITABLE HABITAT FOR EXOTIC SPECIES OF CONCERN.	16
4.1 Different smallmouth and largemouth bass habitats preferences as they affect predation on salmonids.....	17
5.0 ASSESSMENT OF THE RISK OF EXOTIC SPECIES INTRODUCTION TO SKAHA LAKE AND RECOMMENDATIONS FOR YEAR 3	18
5.1 Recommendations for year 3 sampling.....	20
6.0 REFERENCES	21
APPENDIX A	Required Permits
APPENDIX B	Literature review of habitat requirements for bluegill.
APPENDIX C	Data and CPUE for angle sampling
APPENDIX D	Data and CPUE for beach seining
APPENDIX E	Data and CPUE for electrofisher boat
APPENDIX F	Data and CPUE for gill netting
APPENDIX G	Data and CPUE for minnow trapping
APPENDIX H	Data and CPUE for trapnetting
APPENDIX I	Species codes

LIST OF FIGURES, TABLES AND PHOTOGRAPHS

Figure 1. Overview map of the study area.....	2
Figure 2. Sampling sites on South Okanagan Lake.....	9
Figure 3. Sampling sites on Penticton Channel.....	10
Figure 4. Sampling sites on Skaha Lake	11
Figure 5. Sampling sites on Vaseux lake	12
Figure 6. Sampling sites on Okanagan River Channel	13
Figure 7. Sampling sites on Osoyoos Lake	14
Figure 8. Bathymetric map of Skaha Lake.....	16
Figure 9. Bathymetric map of Osoyoos Lake.....	16
 Table 1. Methods and locations for sampling exotic fishes of concern	4
Table 2. Summary of 2001 catch by fishing location	8
Table 3. Summary of Exotic fish risk assessment.....	19
 Photo 1. Angling in Vaseux Lake (AG 4).....	4
Photo 2. Angling in the Okanagan River Channel (AG 10).....	4
Photo 3. Beach seining Okanagan Lake (BS 4).....	5
Photo 4. Beach seining Osoyoos lake (BS 8).....	5
Photo 5. Electrofishing boat	5
Photo 6. Electrofishing in Osoyoos Lake (EF-b 10).....	5
Photo 7. Minnow trapping in the Penticton Oxbows (MT 7a).....	6
Photo 8. Minnow trap set in Vaseux Lake (MT17).....	6
Photo 9. Minnow trapping in Okanagan River side-channel (MT23a).....	6
Photo 10. Trap net set in Vaseux Lake (TN 2).....	7
Photo 11. Yellow perch, largemouth bass & pumpkinseed caught in Trap net (TN 2).....	7
Photo 12. Bluegill (<i>Lepomis macrochirus</i>) from Osoyoos Lake (EF-b 10).....	15

1.0 INTRODUCTION

1.1 Project Background

This report summarizes the second year of the three-year study “Evaluation of an experimental re-introduction of sockeye salmon into Skaha Lake”. The Okanagan sockeye salmon is one of the last two significant populations in the Columbia River system. The other being the Wenatchee River stock in Washington State. Abundance of this stock has declined and fluctuated dramatically in the last fifty years (Hyatt & Rankin 1999). Anadromous sockeye probably populated many upstream waters at one time and the Okanagan Nation and tribes in the U.S. have proposed re-introducing the species into Skaha and possibly Okanagan Lake, which have larger rearing capacities than Osoyoos Lake where juvenile sockeye now spend their first year (see Figure 1). McIntyre Dam is largely impassible for sockeye.

The Bonneville Power Authority (BPA) along with the Colville Confederated Tribes (CCT) and the Okanagan Nation Fisheries Commission (ONFC) are evaluating the proposal for a re-introduction of sockeye salmon into Skaha Lake. The ONFC was retained for project management and implementation of the data field collection for this report which covers YEAR 2 of Objective 2, the ‘Exotic Species Risk Assessment’.

1.2 Objective 2 Scope

The concern implicit in Objective 2 is the possibility of undesirable exotic fish passage to and colonization of upstream areas. A number of exotic fish not indigenous to the Okanagan have become widely established. Some of these are found only below McIntyre Dam which is generally a barrier to fish migration but with removal or changes in the dam structure, they could extend their range upstream and colonize waters such as Vaseux, Skaha and Okanagan Lakes. These populations are referred to as the ‘exotic fishes of concern’.

Objective 2 evaluates the potential risks through the following tasks:

- ◆ Task A: continue to review available fish inventory information in the Okanagan River system, although last years report was considered exhaustive.
- ◆ Task B: repeat the inventory of presence or absence of exotic fish species and habitat use above and below McIntyre Dam.
- ◆ Task C: complete a literature review of habitat requirements of additional exotic species of concern. This was completed for bluegill after finding it in Osoyoos Lake during 2001 sampling.
- ◆ Task D: assess the availability of suitable habitat for species of concern in the study area above McIntyre Dam.

1.3 Project Study Area

The study area remains the same as for YEAR 1, i.e. below McIntyre Dam encompassing the north and central basin of Osoyoos Lake and the Okanagan River channel; and above McIntyre Dam including Okanagan River, Vaseux Lake, Skaha Lake and the southern portion of Okanagan Lake (see Figure 1). Barriers to fish migration at dams located at the outlets of Skaha and Okanagan Lakes have provisions for fish passage but are not in operation.

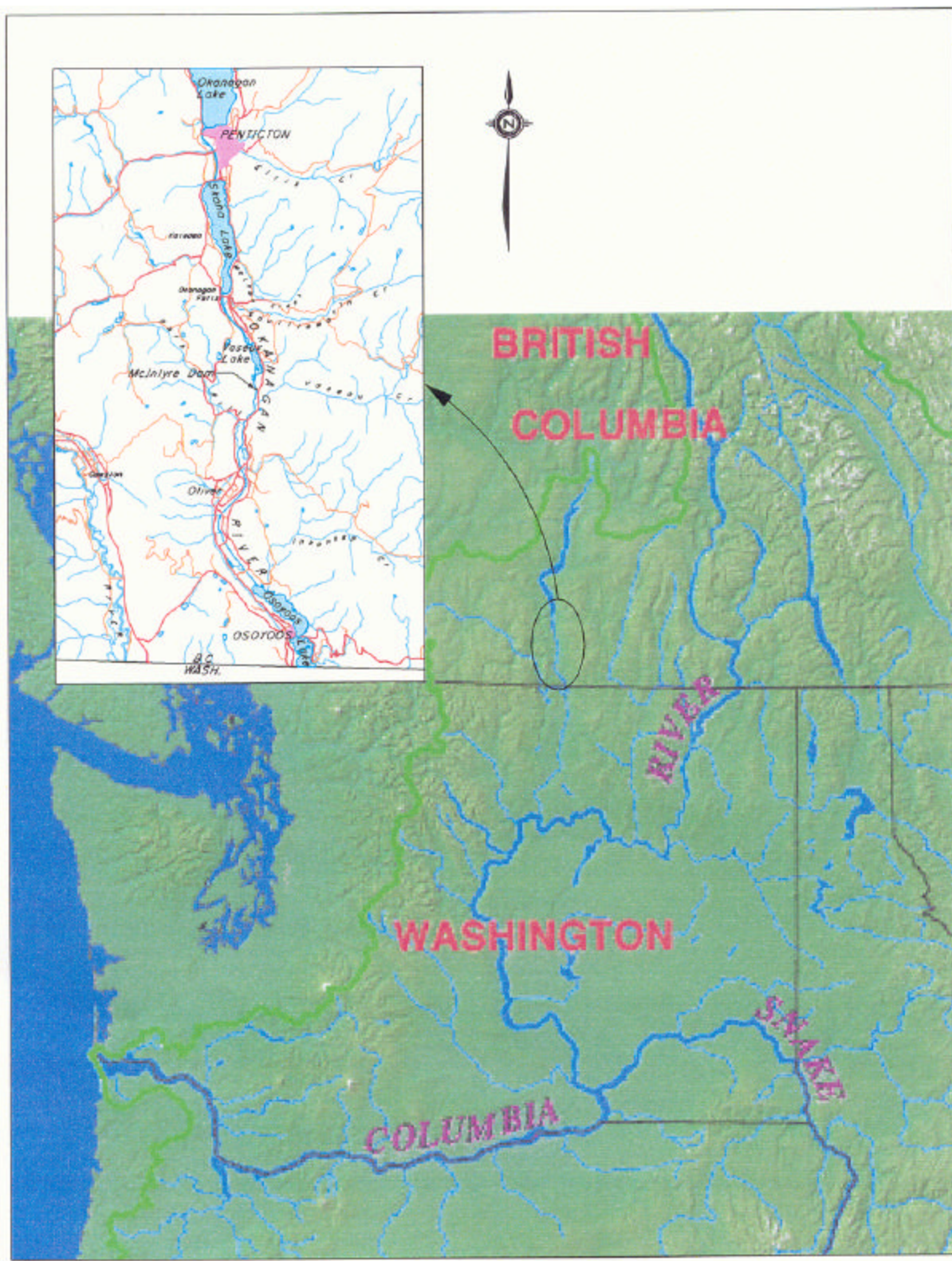


Figure 1. Overview map of the study area

2.0 INVENTORY OF EXOTIC FISH SPECIES

To confirm the extent of exotic fish presence and distribution as indicated by the literature review and after one year of sampling, the ONFC used a wide variety of capture techniques and sampled a wide range of habitats within the study areas. The sampling plan was based on the YEAR 1 report and recommendations. ONFC was responsible for field data collections and project management. Glenfir Resources was retained to provide quality control for the program.

The sampling in YEAR 2 targeted the exotic species of concern and areas of their likely habitat determined in YEAR 1. These include,

1. Fishing in the oxbows of Penticton channel and the Okanagan River Channel to see if these distinct habitats harbor exotic fish species other than those already found there,
2. minnow trapping sites in areas not sampled in 2000,
3. beach seine the south end of Okanagan Lake,
4. sample by angling and trap netting in and above Vaseux Lake to determine how far up the basin largemouth bass and black crappie have migrated,
5. fishing for black bullheads in South Okanagan Lake to note the rate of colonization,
6. review literature on the interactions between kokanee and rainbow trout, and the exotic fishes of concern.

2.1 Exotic fish inventory methods and results

ONFC conducted the exotic fish inventory in accordance with all required permits from the Ministry of Water, Land and Air Protection (MOWLAP) and Fisheries and Oceans Canada (DFO) as noted in Appendix A.

Sampling was conducted from April to November to cover migrations of fish species utilizing different habitat types during different times of the year. Sampling sites were established in YEAR 1, after which several recommendations were made to focus on the exotic species of concern by targeting their habitat types. Table 1 outlines the sampling methods used during the four sampling seasons and selected locations. Details of each sampling method and fish caught are outlined in Sections 2.1.1 to 2.1.6.

Table 1. Methods and locations for sampling exotic fishes of concern

Method	Times	Locations	Species targeted
Angling	May, September & November	Vaseux lake, Okanagan River, Penticton oxbows	black crappie, largemouth bass
beach seining	May/June, September & November	South Okanagan and Osoyoos Lake	13 littoral fish species
electrofishing-boat	April, June, August & November	South Okanagan, Skaha & Osoyoos Lake	18 littoral fish species
gill netting	August	Osoyoos Lake	walleye & pelagic species
minnow trapping	April/May, July, & November	general	small individuals
Floating trap net	July and September	Vaseux Lake	black crappie and largemouth bass

The catch per unit effort (CPUE) of each kind of sampling gear was recorded. A summary of species caught by each kind of fishing gear is presented in Table 2, and detailed summaries are in Appendices C-H.

2.1.1 Angling

After questioning local fishermen about preferred baits and fishing locations the ONFC field crew members chose casting rods to fish for black crappie in Vaseux Lake (photo 1) and for any available fish in Penticton oxbows, Oliver oxbows and VDS1 (photo 2). See Appendix C for details.

Species caught: smallmouth bass, yellow perch, northern pike minnow and common carp.



Photo 1. Angling in Vaseux Lake (AG 4)



Photo 2. Angling in the Okanagan River Channel (AG 10)

2.1.2 Beach seining

In accordance with YEAR 1 recommendations beach seines were used in the southern portion of Okanagan Lake (Photo 3) and Osoyoos Lake (Photo 4) (see Appendix D). A large and a small seine net were used. The larger was 30 m long 3 m deep with mesh sizes (stretch measure) of 3 mm in the bunt end and 10 and 25 mm panels in each wing. The smaller seine was 10 m long, 1.5 deep with 3.5 mm mesh size throughout. As anticipated, seines employed from shore over smooth substrate caught littoral zone type fish. In addition to 18 identified species some juvenile fish were unidentifiable.

<u>Species caught:</u>	black crappie	black bullheads	peamouth chub
prickly sculpins	common carp	redside shiner	largemouth bass
sockeye fry	northern pike minnow	smallmouth bass	suckers spp.
yellow perch	whitefish spp.		



Photo 3. Beach seining
Okanagan Lake (BS 4)



Photo 4. Beach seining
Osoyoos Lake (BS 8)

2.1.3 Electrofishing

Night surveys with the boat mounted electrofisher (Photos 5 and 6) were conducted in April, June, August and November (Appendix E). The boat, equipped with a Smith-root model 7.5 GPP electrofisher, sampled transects parallel to the shoreline, in water depths of less than 3.5 meters. Voltage was kept constant at 500 volts (DC) with the duty cycles varying between 20% and 55%. The majority of electrofishing was undertaken at outputs between 3.8-6.5 Amps (Resource Inventory Committee). Bluegill was caught in Osoyoos Lake for the first time on record.

<u>Species caught:</u>	black crappie	black bullhead	bluegill (Photo 12),
burbot	common carp	kokanee	northern pike minnow
largemouth bass	peamouth chub	pumpkinseed	rainbow trout
redside shiner	prickly sculpin	smallmouth bass	suckers spp.
sockeye	whitefish spp.	yellow perch.	



Photo 5. Electrofishing boat



Photo 6. Electrofishing in Osoyoos
Lake (EF-b 10)

2.1.4 Gillnetting

Gillnets were used to target for walleye in Osoyoos Lake in areas identified in the YEAR 1 recommendations. Gillnetting occurred during the evening of August 29 using 3 to 5 standard gangs (1.8m long X 2.4m deep) of varied mesh (5.0, 6.25, 7.5 and 8.75 cm). The gill net at site GN1 was submerged 20m deep for 6.5 hours. The gillnet at site 2 was set 4 m deep for approximately 2.5 hours (Appendix F).

Species caught: common carp, northern pike minnow, suckers spp. and adult sockeye.

2.1.5 Minnow trapping

Minnow traps were placed throughout much of the study area in April, July and November for 24 hour fishing periods. The trap mesh was 6 mm and the circular opening was 2 cm diameter. The traps were baited with canned sardines or salmon roe. Features of sampling sites added during YEAR 2 were Penticton oxbows (Photo 7) and Okanagan River side channel (Photo 9; Appendix G). Usually, 3 to 4 minnow traps were set at each site.

Species caught:

black bullhead
prickly sculpin
common carp
kokanee
largemouth bass
pumpkinseed
rainbow trout
reidside shiner
smallmouth bass
suckers spp.
yellow perch
northern pike minnow.



Photo 7. Minnow trapping in the Penticton Oxbows (MT 7a)



Photo 8. Minnow trap set in Vaseux Lake (MT17)



Photo 9. Minnow trapping in Okanagan River side-channel (MT23a)

2.1.6 Trap netting

A floating trap was fished for two 24 hour periods at both the north end and the outlet of Vaseux Lake (Photo 10 & 11) targeting for black crappie. The net was set in water 1 to 3 m deep, 5 m offshore (see Appendix H for data and CPUE). During trap netting, no black crappie were caught.

Species caught: black bullhead, largemouth bass (photo 12), pumpkinseed sunfish and yellow perch.



Photo 10. Trap net set in Vaseux Lake (TN 2)



Photo 11. Yellow perch, largemouth bass & pumpkinseed caught in Trap net (TN 2)

2.2 Inventory summary

The discovery of bluegill in Osoyoos Lake brings the number of “exotic fishes of concern” in the study area to seven. They are black bullhead, brown bullhead, black crappie, bluegill, largemouth bass, tench and walleye. Of these species black bullhead are found as far as Skaha Lake; largemouth bass as far upstream as Vaseux Lake. Black crappie, bluegill and tench have been found only in Osoyoos Lake, and brown bullhead and walleye have not yet been caught in the study area. Table 2 summarizes the fish species caught during 2001 sampling. The catch data and CPUE are found in Appendices C through H, and the species codes are in Appendix I. Figures 2 through 7 show sampling sites located on composite air photos.

Table 2. Summary of 2001 catch by fishing location

Species found during 2001 sampling	Above McIntyre Dam				Below McIntyre Dam	
	Okanagan Lake South	Skaha Lake	Vaseux Lake	Okanagan River channel & oxbow	Okanagan River channel	Osoyoos Lake
Burbot	EF-b					
Black crappie						BS, EF-b
Black bullhead		EF-b, MT	MT, TN	MT	MT	BS
Brown bullhead						
Bluegill sunfish						EF-b
Prickly sculpin	BS, EF-b, MT	EF-b, MT	MT	MT	MT	BS, EF-b, MT
Chinook salmon						
Common carp	EF-b	EF-b		MT	AG	AG, BS, EF-b, GN
Eastern brook trout						
Goldfish						
Kokanee		EF-b		MT		
Largemouth bass			MT, TN		MT	BS, EF-b, MT
Lake chub						
Northern pike minnow	BS, EF-b, MT	EF-b		AG, MT	AG	EF-b, GN
Peamouth chub	BS, EF-b	EF-b				BS, EF-b
Pumpkinseed		EF-b	MT, TN			BS, EF-b
Rainbow trout		EF-b				EF-b, MT
Redside shiner	BS, EF-b, MT			MT		
Sockeye salmon						BS, EF-b, GN
Smallmouth bass	MT	EF-b	AG, MT	MT	AG, MT	BS, EF-b
Sucker spp.	BS, EF-b	EF-b		MT		EF-b, GN
Tench						
Whitefish spp.	BS, EF-b	EF-b				BS, EF-b
Walleye						
Yellow perch		EF-b, MT	AG, MT, TN		MT	BS, EF-b, MT

Fish capture methods	EF-b	electrofishing boat
	MT	minnow trapping
	GN	gillnetting
	AG	angling
	BS	beach seining
	TN	trap netting



Figure 2. Sampling sites on South Okanagan Lake

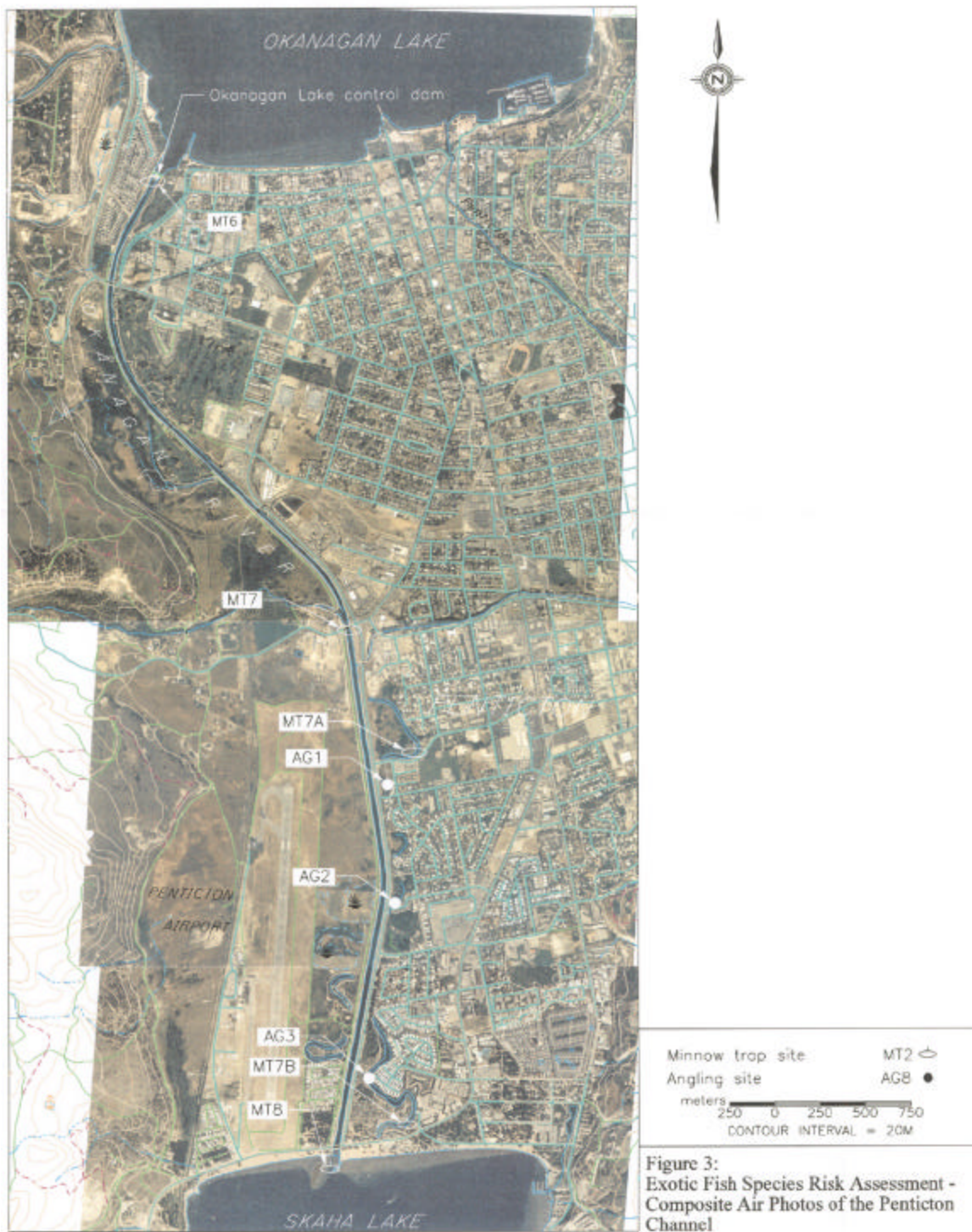


Figure 3. Sampling sites on Penticton Channel



Figure 4. Sampling sites on Skaha Lake



Figure 5. Sampling sites on Vaseux Lake

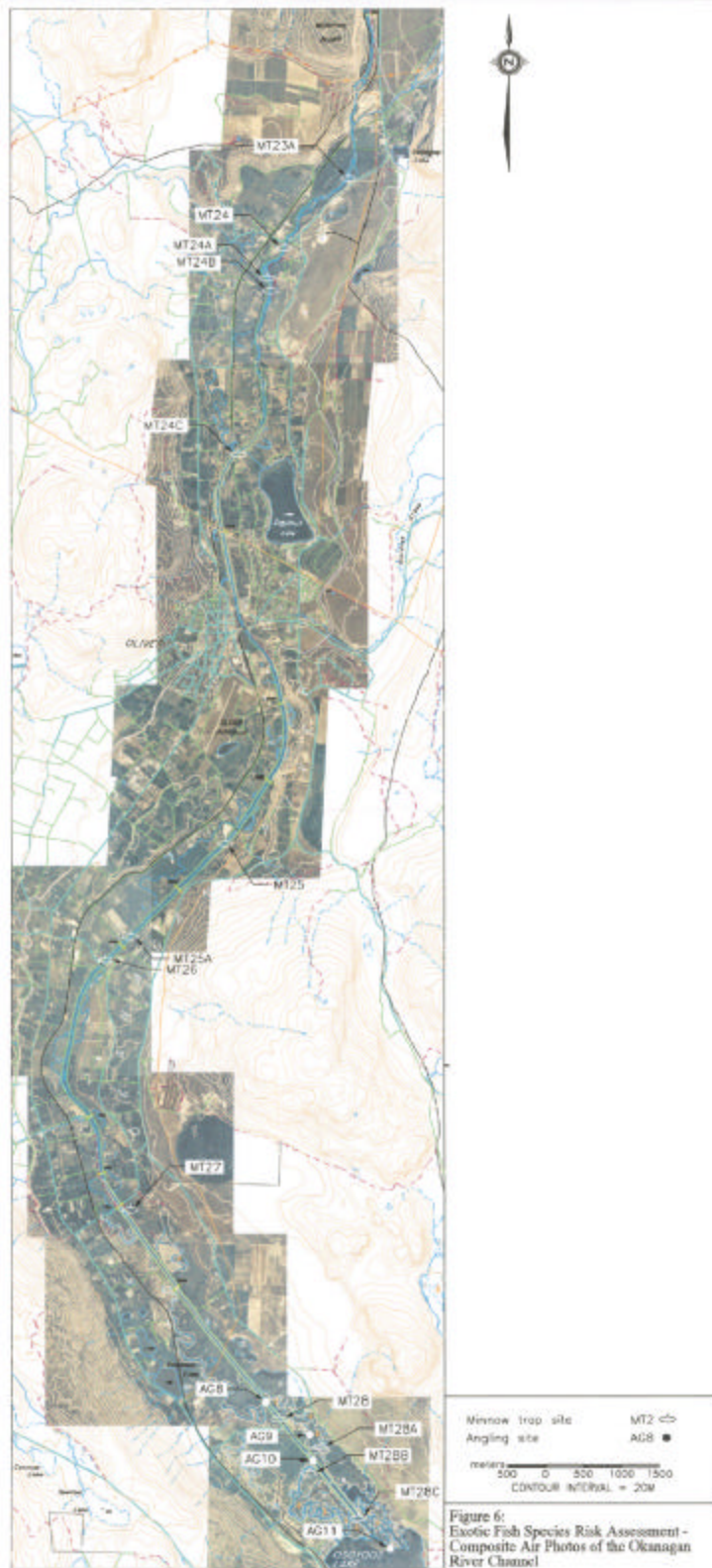


Figure 6. Sampling sites on Okanagan River channel

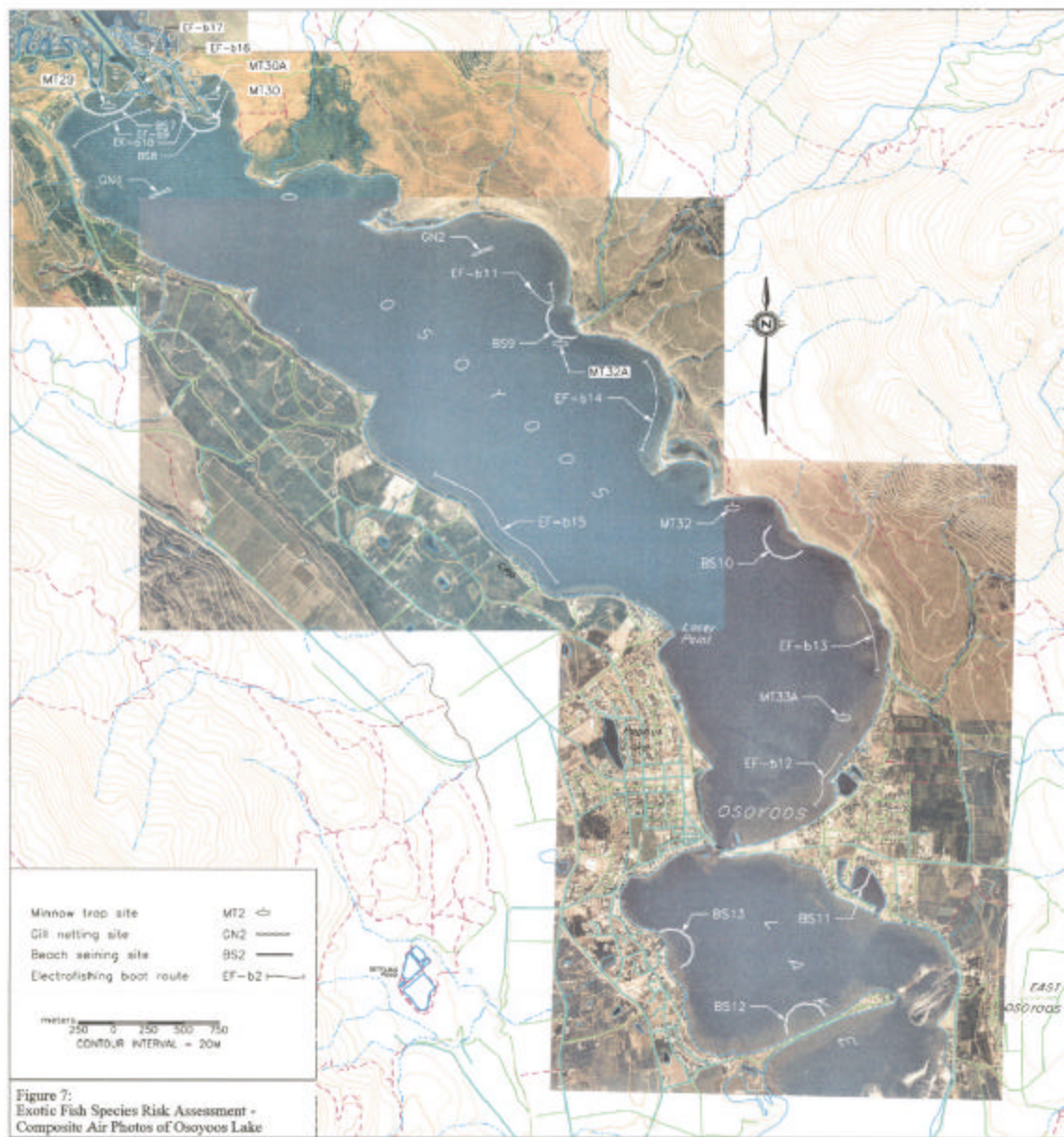


Figure 7: Sampling sites on Osoyoos Lake

3.0 LITERATURE REVIEW OF THE HABITAT PREFERENCES OF AN ADDITIONAL EXOTIC FISHES OF CONCERN

The YEAR 1 report identified five exotic fishes of concern; black and brown bullhead, black crappie, largemouth bass, tench and walleye. During sampling this year, one bluegill (*Lepomis macrochirus*) was caught in Osoyoos Lake. Bluegill (Photo 12) is an exotic species and a literature review was undertaken to identify their habitat preferences (Appendix B).

Bluegill prefer the shallow, weedy, warm water of large and small lakes, ponds and heavily vegetated, slow moving areas of small rivers and large creeks with sand, mud, or gravel bottoms. Juvenile bluegills are typically found in the littoral zone of lakes, but when they reach >50-75mm they move into open-water within the limnetic zone. Large bluegills stay in deeper water during the day and move to near shore areas in the morning and evening to feed.

In winter, bluegill may congregate and continue feeding in deeper water; in summer they utilize small territories and move very little. Bluegills are known to hybridize with pumpkinseed sunfish, both of which are predated on by largemouth bass. Large populations of bluegill can be serious competition for other species feeding on bottom organisms.

Bluegills consume a wide range of food items, including chironomids, insects, mullusks, nematodes and algae but they rarely eat fish. Large individuals feed predominantly on limnetic zooplankton, targeting large cladocerans preferentially. Based upon preferential foods, bluegill could be a competitor with juvenile sockeye or kokanee.



Photo 12. Bluegill (*Lepomis macrochirus*) from Osoyoos Lake (EF-b 10)

4.0 AVAILABILITY OF SUITABLE HABITAT FOR EXOTIC SPECIES OF CONCERN

The possibility of undesirable exotic fish moving to areas upstream of McIntyre Dam such as Skaha and/or Okanagan Lakes is a concern because if such habitats prove suitable to exotic species they may adapt for long-term colonization. The Skaha Lake littoral zone (Figure 8) has rooted aquatic vegetation along the shallow eastern and western shorelines thus providing habitat for fish which prefer such areas. Given access these exotic species could survive in Skaha Lake but not necessarily flourish as well as they do in Osoyoos Lake with its shallow mean depth and extensive littoral area.

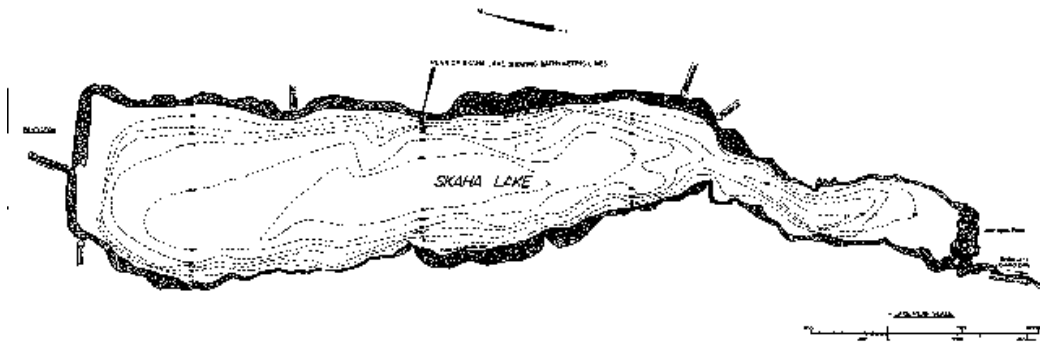


Figure 8. Bathymetric Map of Skaha Lake

Along its large littoral area, Osoyoos Lake (Figure 9) supports many fish species, including an important nursery ground for young sockeye salmon (Anon, 1972). There is a high density of fish in all habitats of Osoyoos Lake with a large percentage of non-salmonids. Bluegill, found during sampling in YEAR 2, inhabit shallow, weedy, littoral areas as juveniles. Once bluegills reach >50-75mm they move into open-water within the limnetic zone. Bullheads already exist in Skaha Lake. Black crappie, largemouth bass and tench typically inhabit littoral areas like those found in Osoyoos Lake and could inhabit Skaha Lake. Walleye are found in both the pelagic and littoral areas of lakes, they are also piscivorous and prey heavily on juvenile sockeye.

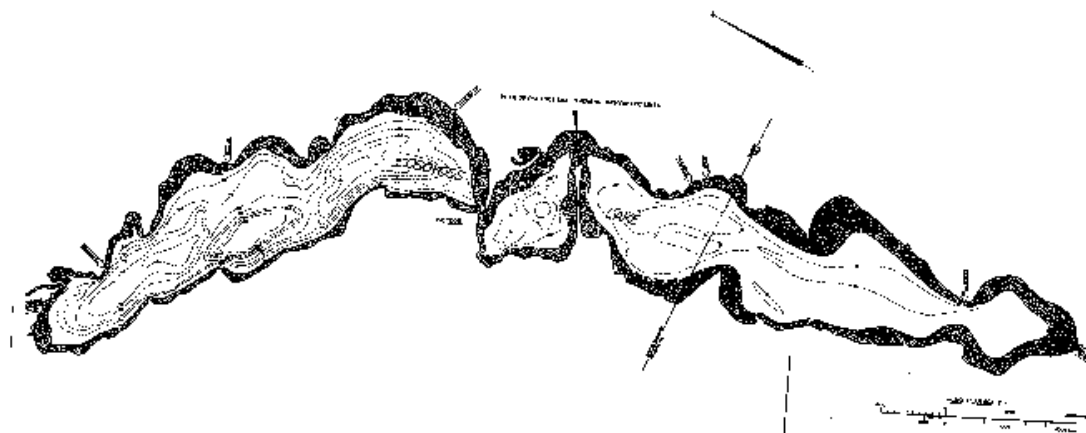


Figure 9. Bathymetric map of Osoyoos Lake

4.1 Different smallmouth and largemouth bass habitats preferences as they affect predation on salmonids

During the YEAR 1 review meeting (March 1st & 2nd, 2001), questions were raised concerning the differences between largemouth and smallmouth bass since the latter are well established throughout the Okanagan Basin where they coexist with kokanee and other native species, whereas largemouth bass are found as far upstream as Vaseux Lake and is an 'exotic species of concern'. The differences in habitat preference and predatory instincts between smallmouth and largemouth bass may account for the propensity of the former to become established.

Smallmouth bass prefer large clear lakes with rocky shoals (Turner and MacCrimmon 1970; Coble 1975). In lakes and reservoirs, they prefer cooler areas, such as drop-offs, away from vegetation and in water greater than 12m deep (Scott and Crossman 1973; Coble 1975). Largemouth bass conversely thrive best in warm, shallow, weedy lakes or in river backwaters (Newbury and Gaboury 1993) and are rarely caught below 6 metres depth (Scott and Crossman 1973).

The food of largemouth bass changes as the fish grow. Initially they concentrate on plankton and insects, but fish and frogs become important later (Edwards et al 1983; Carl et al 1967; Diana 1983; Simpson and Wallace 1978) and adults are considered to be primarily fish-eating. These adult largemouth bass are territorial ambush predators, which would tend to minimize their impact on pelagic species such as kokanee and rainbow trout (Naito 2000).

Adult smallmouth bass primarily feed on fish and crayfish (Edwards 1983). Introduced smallmouth bass (*Micropterus dolomieu*) were considered to be a potential cause of increased predation on the juvenile salmonid population in the John Day Reservoir. Ultrasonic tracking showed limited spatial and temporal overlap between smallmouth and juvenile sockeye salmon. Substantial overlap occurred only in the littoral zone during the migration of the emerging sockeye fry into the lake and during migration of smolts from the lake. Smallmouth bass greater than 150mm total length took 28% of their diet as juvenile salmonids while in the lake and 38% as smolts while in the river (Fayram & Sibley, 2000).

The habitat of smallmouth bass overlap more with salmonids than largemouth bass, as smallmouth are found slightly deeper and cooler, however not necessarily pelagic (such as salmonids) whereas largemouth bass are warm water species making smallmouth bass a more aggressive predator on salmonid species.

5.0 ASSESSMENT OF THE RISK OF EXOTIC SPECIES INTRODUCTION TO SKAHA LAKE AND RECOMMENDATIONS FOR YEAR 3

Investigations in YEARS 1 and 2 suggest that two main problems could arise from any introductions of undesirable exotic species into Skaha Lake. First they might be significant predators on young salmon and second they might become competitors for food and habitat.

There are a number of barriers to fish migration up the Okanagan River. For instance, the control dam at the outlet of Okanagan Lake is a barrier to black bullheads that exist in Skaha Lake and the control dam at the outlet of Skaha Lake is a barrier to largemouth bass that are well established in Vaseux Lake above McIntyre Dam. Without the latter dam, exotic fish such as black crappie, bluegill and tench found in Osoyoos Lake would be able to migrate upstream as far as McIntyre Dam. Walleye are found in the Okanagan River south of the International border and there is no apparent physical barrier to their movement north.

Osoyoos and Skaha Lakes habitats differ primarily in the amount of littoral area. Skaha Lake contains rooted aquatic vegetation along only the eastern and western shorelines whereas, Osoyoos Lake provides considerable littoral habitat suitable for species such as largemouth bass, black crappie, bullhead, bluegill sunfish and tench. If access was provided to Skaha Lake, exotic species could probably survive there but perhaps not as well as they do in Osoyoos Lake.

From the YEAR 1 literature review and sampling it was concluded that there were five exotic species of concern i.e. black crappie, black bullhead, largemouth bass, tench and walleye. In addition during YEAR 1 sampling, bluegill that had never before been documented in the Okanagan Basin was caught in Osoyoos Lake thus adding a sixth.

Juvenile bluegills are typically found in littoral zones, but on reaching about 50-75mm they move into open-water within the limnetic zone where they feed predominantly on limnetic zooplankton. Fish are rarely eaten so they are of little consequence for deep pelagic species like kokanee, sockeye and rainbow trout.

The risks associated with the introduction of black crappie (found only in Osoyoos Lake) to upstream waters are that they travel in open waters and feed on a variety of very small fishes which could include sockeye as well as plankton.

Largemouth bass (already found in Vaseux Lake above McIntyre Dam) are a predatory fish that feed in the littoral areas. By studying smallmouth (established throughout the Okanagan Basin) it was hoped to extrapolate findings to the somewhat similar habitats and feeding preferences of largemouth bass (a fish of the same genus). The literature search concluded that the two species use slightly different areas with smallmouth bass using cooler deeper areas whereas largemouth bass thrive best in warm, shallow, weedy areas of lakes or river backwaters. Both largemouth and smallmouth bass are piscivorous but largemouth bass are described as territorial ambush predators, which behavior would seem likely to make them comparatively less damaging to pelagic salmonids. Smallmouth feed on sockeye fry primarily in the littoral zone where the young fish are abundant after emergence and on sockeye smolts during their out-migration.

Since black bullhead are already found in Skaha Lake, for the purposes of this project they are no longer considered an exotic species of concern.

Tench (not caught therefore most likely not an established population) is a carp-like fish that would most likely have the same role in the ecosystem that carp have, such as competition for food with native species. Walleye (found as far as Mallot, Washington in the lower Okanogan River) rapidly travel long distances and are known to be predatory piscivores. The risks associated with the upstream migration and colonization of exotic species into Skaha and South Okanogan Lakes from years 1 and 2 are summarized in Table 3.

Table 3. Summary of results from YEAR 1 and 2 and perceived risks

Exotic species of concern	Geographical Range of species within South Okanagan Basin	Habitat preferences and species interactions	Skaha Lake areas thought likely to be colonized	Exotic Fish Risk Assessment
Black crappie	Caught in Osoyoos Lake oxbows; not above McIntyre Dam	Lake littoral zone. Adults feed on very small fish.	Littoral	Little interaction with salmonids
Largemouth bass	Vaseux and Osoyoos Lake where they have coexisted with salmonids for 70 years	Warm, shallow, weedy areas. Piscivorous but predation would be minimized on pelagic species except during emergence and smolts.	Littoral	Would feed on salmonids when they pass through the littoral zones
Tench	Not in Osoyoos, Skaha or South Okanagan lakes; caught below Zosel Dam	Littoral areas of lakes, or swamps, particularly where organic material is substantial	Littoral and backwater oxbows	Rare in Osoyoos Lake & most likely have little interaction with salmonids.
Walleye	Not in Osoyoos, Skaha or South Okanagan lakes; established population in the Columbia mainstem	Littoral and pelagic areas of Lakes seasonally inhabit the same areas, and are known to prey on juvenile salmonids.	There is suitable habitat in Skaha & Osoyoos Lake	Would have an impact on resident salmonids if they established themselves in the Okanagan Basin.
Bluegill	In Osoyoos Lake.	Littoral zone; adults move into limnetic open-water; feed predominantly on limnetic zooplankton and rarely eat fish.	Littoral as juveniles and limnetic open water as adults.	Occupy different habitat and feed on zooplankton which makes them of little consequence to deep pelagic species like kokanee, sockeye and rainbow trout.

5.1 Recommendations for year 3 sampling

In this final year of sampling ensure that there are no remaining gaps in data, recommendations include,

1. Trapping and angling for black crappie in Vaseux Lake in the spring.
2. Sampling in the Okanagan River by backpack electrofishing, angling, and/or trap netting.
3. Sampling oxbows in Penticton and Oliver by angling and perhaps trapping.
4. Design a more vigorous and unbiased (non-angling) sampling plan to assess predation on sockeye smolts in the forebay and tailrace of Zosel Dam.
5. Assess the predation by bass and other fishes on sockeye fry emerging from the Okanagan River.

6.0 REFERENCES¹

Anonymous. 1972. Limnology of the Mainstem Okanagan lakes. Bulletin No. 3. Study Committee, Canada-British Columbia- Okanagan Basin Agreement, Penticton, B.C., 4pp.

Carl, G.C., W.A. Clements and C.C. Lindsey. 1967. The freshwater fishes of British Columbia. BC Provincial Museum Handbook no. 5, 192p.

Coble, D. W. 1975. Smallmouth bass. Pages 21-22 in H. Clepper, ed. Black bass biology and management. Sport Fish. Inst., Washington, DC.

Connolly, P.J and B.E. Rieman. Population Dynamics of Walleye and smallmouth bass and potential predation on salmonid smolts in John Day Reservoir. Oregon Department of fish and Wildlife. Submitted to: North American Journal of Fisheries Management.

Diana, J. 1983. Oxygen consumption by largemouth bass under constant and fluctuating thermal regimes. Canadian Journal of Zoology 61(8):1892-1895.

Edwards, E.A., G. Gebhart and O.E. Maughan. 1983. Habitat Suitability Information: Smallmouth bass. Fish and Wildlife Service, US Department of the Interior. FWS/OBS-82/10.36.

Fayram, A.H. and T.H. Sibley. 2000. Impact of Predation by smallmouth bass on sockeye salmon in Lake Washington, Washington. North American Journal of Fisheries Management. 20:81-89 . (cited in Edwards et al 1983)

Hyatt, K.D. and D.P. Rankin. 1999. An Evaluation of Okanagan Sockeye Salmon Escapement Objectives. Pacific Stock Assessment Review committee, working paper S99-18. (not citable).

Naito, G. 2000. Presence and distribution of exotic fish species in the Okanagan watershed. Prepared for the Okanagan Nation Fisheries Commission.

Newbury, R.W. and M.N. Gaboury. 1993. Stream analysis and fish habitat design – A field manual. Newbury Hydraulics Ltd. and the Manitoba Habitat Heritage Corporation.

Poe, T.P, H.C Hansel, S. Vigg, D.E. Palmer and L.A. Prendergast. Predation by Northern squawfish, walleye, smallmouth bass and channel catfish in a mainstem Columbia River Reservoir: Feeding ecology during the salmonid smolt out-migration. U.S. Fish and Wildlife Service. Submitted to: Transaction of the American Fisheries Society.

Resource Inventory Committee. 1999. Overview fish and fish habitat inventory methodology. Prepared by BC Ministry of Fisheries – Fisheries Inventory Section.

Reynolds, J. 1965. Life history of smallmouth bass, (*Micropterus dolomieu*) Lacepede, in the Des Moines River, Boone County, Iowa. Iowa State J. Sci. 39:417-436.

¹ Reference used to produce literature reviews listed within the appendisized literature reviews

Scott, W.B. and E.J. Crossman. 1973. *Freshwater fishes of Canada*. Bulletin 184. Fisheries Research Board of Canada.

Simpson and Wallace. 1978. *Fishes of Idaho*. Moscow: University Press of Idaho.

Turner, G. E. and H. R. MacCrimmon. 1970. Reproduction and growth of smallmouth bass, *Micropterus dolomieu*, in a Precambian Lake. J. Fish. Res. Board Canada. 27:395-400.

APPENDIX A

REQUIRED SAMPLING
PERMITS



Province of
British Columbia

MINISTRY OF
ENVIRONMENT,
LANDS AND PARKS

BC
Environment

1259 Dalhousie Drive
Kamloops BC
V2C 5Z5
Telephone: (604) 371-8200
Facsimile: (604) 828-4000

File: 34770-20

April 10, 2001

Okanagan Nation Fisheries Commission
3255 C Shannon Lake Road
Westbank BC
V4T 1V4

Dear ,

Re: Fish Collecting Permit

I have enclosed your Fish Collecting Permit issued from 4/1/2001 to 11/30/2001 along with Receipt No. n/a.

Please be advised that a summary report of collecting activities must be submitted to our office within 90 days of the expiry date of this permit. Interim reports may also be required and shall be submitted upon request of the permit issuer.

Please contact me if you have any questions regarding this permit.

Yours truly,

Ian A. McGregor
I.A. McGregor
Fisheries Section Head

Enclosure

cc:



Province of
British Columbia

Ministry of
Environment,
Land and Parks

BC
Environment

1250 Dalhousie Drive
Kamloops BC
V2C 6Z8
Telephone: (250) 371-0200
Facsimile: (250) 320-4000

File: 34770-20
Permit No. 01-30-0510

SCIENTIFIC COLLECTION PERMIT

Okanagan Nation Fisheries Commission

Permittee(s): Dawn Michin, Kari Long, Howie Wright, Sheryl Lawrence, Herb Alex,
Fabien Akela and unnamed assistants.

The PERMITTEE is hereby authorized under section 102 of the Wildlife Act, SBC 57/82,
and as provided in section 18 of B.C. Reg. 125/90, to collect fish for scientific purposes
subject to the general conditions and restrictions set forth herein.

Permitted Waters: Okanagan Lake, Okanagan River, Skaha Lake, Vaseux Lake, Osoyoos
Lake and connected outflows to the Okanagan River near Penticton &
Oliver.

Permitted Times: Start: 01-Apr-01 Expiry: 30-Nov-01

Permitted Species: All Species

Permitted Gear: Angling Dock/ack Electroshocker Beach Seine
Gill Net Minnow Trap

Restrictions:

AUTHORIZED BY:

Ian A. McGregor
Ian A. McGregor
Fisheries Section Head

April 12/01
Date

cc:

Paid \$25.00

Receipts n/a

GENERAL CONDITIONS

This permit is issued without prejudice to the title and rights of the Okanagan Nation.

1. This collecting permit is not valid
 - (a) in national parks,
 - (b) in provincial parks unless approved in writing by regional staff of BC Parks,
 - (c) for salmon other than kokanee, or
 - (d) for collecting fish by angling unless the permittee and crew members possess a valid angling licence.
2. This permit is valid only for the activities approved on the application form and in accordance with any restrictions set out therein.
3. The Permittee must notify the district conservation officer(s) of the permittee's schedule for collection activities in their areas prior to the commencement of those activities.
4. This permit must be carried by the permittee while engaged in fish collecting and produced for inspection upon request of a conservation officer, fishery officer or constable.
5. This permit is valid only for trained, qualified staff named in the Application. The permittee will comply with all Worker's Compensation Board requirements and other regulatory requirements.
6. Any specimens surplus to scientific requirements and any species not authorized for collection shall be immediately and carefully released alive at the point of capture.
7. Fish collected under authority of this permit shall not be used for food or any purpose other than the objectives set out in the approved application for a scientific collection permit. The permittee shall not sell, barter, trade, or give away, or offer to sell, barter, trade or give away fish collected under authority of this permit. Dead fish shall be disposed of in a manner that will not constitute a health hazard, nuisance or a threat to wildlife.
8. No fish collected under authority of this permit shall be transported alive or transplanted to another body of water unless separately authorized by the Federal/Provincial Committee on live fish permits.
9. The permittee shall submit to the Regional Fisheries Section Head for the area under consideration the fish collection data within 90 days of completion of the collecting activity. Interim reports and/or sample data cards will be provided upon request to the requesting officer.
10. This collecting permit may be cancelled at any time and shall be surrendered to a Conservation Officer on demand or to the issuer immediately upon receipt of written notice of its cancellation.
11. Ensure staff are always working in water that is 5°C or greater if sampling for presence or absence of fish.

APPENDIX B

LITERATURE REVIEW OF HABITAT REQUIREMENTS FOR EXOTIC SPECIES OF CONCERN (BLUEGILL)

Bluegill – *Lepomis macrochirus*

Bluegill <i>Lepomis macrochirus</i>	Habitat	Inhabits shallow, weedy, warm water of large and small lakes, ponds and heavily vegetated, slow moving areas of small rivers and large creeks (13,14,26,40,41,34,39) with sand, mud, or gravel bottoms (14,42). Within lakes and rivers they can occur in a large variety of habitats including pools, overflow ponds, oxbows, swamps, and man-made impoundments (38). Juvenile bluegill are typically found in the littoral zone to avoid predation (3,19,33). Once bluegills reach a larger size (>50-75mm SL) and become less vulnerable to predation they move into open-water within the limnetic zone (6,19,20,21,23,29). Bluegill can be found in deep water during extreme weather of summer and winter (13). Large bluegills stay in deeper water during the day and move to nearshore areas in the morning and evening to feed (35,40).
	Biology	Bluegills are a warmwater species that have optimum temperatures for growth from 24-30 °C and their growing season is approximately April through October (9). Bluegills have a two-stage life history with juveniles restricted by predators to feeding on littoral-zone invertebrates, while adults feed primarily on open-water zooplankton (20,23). Bluegill reach sexual maturity in Canada by age 2 or 3 for males and 3 or 4 for females (26). The males make and defend nests until fry leave, usually 3-5 days (26). Growth is rapid until they reach approximately 240mm TL after which little growth occurs (4,26). Bluegill can attain lengths of 254-305mm but usually do not exceed 152-203mm with a maximum age of 8-10 years (26). In winter groups retreat to deeper water in winter where they congregate in colonies but continue feeding; in summer they utilize small territories and move very little (26). Bluegill also follow a daily migratory pattern that brings them close to shore at night and into open water during the day (34). Fish sampled from littoral-zone habitat had deeper bodies; had longer pectoral fins; utilized slower, more deliberate searching tactics; and had a higher capture rate of littoral –zone prey than did fish sampled from adjacent open-water habitat (33). Bluegill are known to hybridize with longear, orangespotted, green redbreast, redear, and pumpkinseed sunfishes (26). Spawning: Bluegills are synchronized, repeat spawners and spawn through spring and summer when water temperatures are between 17-31 °C and at water depths of 0.05-4.6m over sand, gravel or mud bottoms (5,6,14,25,38,40,41,42).
	Velocity tolerance	Bluegill prefer warm, shallow, slow-moving or standing water (14,34,40,41,42). Evidence of spreading: The native range of the bluegill is restricted to the fresh waters of eastern and central North America (26).
	Competition & Predation	Competition: Large populations of bluegills can be serious competitors for bottom organisms with other fishes, for example YOY largemouth bass (8,26). Small bluegills and pumpkinseeds overlap in diet and

	<p>habitat use and potentially with other small size-classes of other sunfishes which occupy the vegetated littoral zone (19,23,28).</p> <p>Predation: Generally occurs on juveniles. Predators of juvenile bluegill include all age-classes of bass, <i>Micropterus dolomieu</i> and <i>M. salmoides</i>, older age-classes of yellow perch, <i>Perca flavescens</i>, and all age-classes of northern pike <i>Esox lucius</i> and also adult bluegill (3,4,5,19,21,26,34). Largemouth bass is considered to be the most important of the predators (3,4,19,21).</p> <p>Feeding: Food is generally considered to be insects, crustaceans, and plant material, found on the surface, in the water mass, and off the bottom (13,26,27). Bluegill consume a wide range of food items, including chironomids, cladocerans, copepods, ostracods, amphipods and isopods, flying insects, Odonata nymphs, Ephemeroptera nymphs, trichoptera larvae, mullusks, nematodes and algae with fish rarely eaten (14,24,26,27,29,34,41,42). Bluegill are predominantly diurnal feeders, showing a marked increase in feeding activity at dawn (19). Large bluegill feed predominantly on limnetic zooplankton, feeding preferentially on large cladocerans (20). Feed in early morning or the evening, feed primarily during daylight (34,40).</p>
Physio / chemical tolerances	<p>Oxygen: Bluegills are intolerant of low oxygen levels, often being the first to die due to winterkill (34).</p> <p>Turbidity: Bluegill prefer clear water systems (38,39).</p> <p>Temperature: Temperature tolerance seems to be influenced by the presence of predators with the mean upper avoidance being 29.9 °C in the absence of predators and 33.7 °C in the presence of predators and a preferred temperature of 24.9 – 26.5 °C (7). Rapid changes in temperature can cause mortality in bluegill (27). Bluegill do well in water temperatures of 15.6 – 26.7 °C and up to 29.4 °C (40) and 29.4 – 31.1 °C and can tolerate up to 35.0 °C (34).</p>

WORKS CITED

1. Adams, S.R., T.M. Keevin, K.J. Killgore, and J.J. Hoover. 1999. Stranding Potential of Young Fishes Subjected to Simulated Vessel-Induced Drawdown. *Transactions of the American Fisheries Society* 128: 1230-1234.
2. Bain, M.B. and L.A. Helfrich. 1983. Role of Male Parental Care in Survival of Larval Bluegills. *Transactions of the American Fisheries Society* 112: 47-52.
3. Belk, M.C. 1998. Predator-induced delayed maturity in bluegill sunfish (*Lepomis macrochirus*): variation among populations. *Oecologia* 113: 203-209.
4. Belk, M.C. and L.S. Hales Jr. 1993. Predation-induced differences in growth and reproduction of bluegills (*Lepomis macrochirus*). *Copeia* (4): 1034-1044.
5. Cargnelli, L.M. and M.R. Gross. 1996. The temporal dimension in fish recruitment: birth date, body size, and size-dependent survival in sunfish (bluegill: *Lepomis macrochirus*). *Can. J. Fish. Aquat. Sci.* 53: 360-367.
6. Ehlinger, T.J. 1990. Habitat choice and phenotype-limited feeding efficiency in bluegill: individual differences and trophic polymorphism. *Ecology* 71: 886-896.
7. Fischer, R.U. Jr., E.A. Standora, and J.R. Spotila. 1987. Predator-induced changes in thermoregulation of bluegill, *Lepomis macrochirus*, from a thermally altered reservoir. *Can. J. Fish. Aquat. Sci.* 44:1629-1634.
8. Garvey, J.E., N.A. Dingle, N.S. Donovan, and R.A. Stein. 1998. Exploring spatial and temporal variation within reservoir food webs: predictions for fish assemblages. *Ecological Applications* 8: 104-120.
9. Gutreuter, S., A.D. Bartels, K. Irons, and M.B. Sandheinrich. 1999. Evaluation of the flood-pulse concept based on statistical models of growth of selected fishes of the Upper Mississippi River system. *Can. J. Fish. Aquat. Sci.* 56: 2282-2291.
10. Hanson, C.H. and E. Jacobson. 1985. Orientation of juvenile chinook salmon, *Oncorhynchus tshawytscha*, and bluegill, *Lepomis macrochirus*, to low water velocities under high and low light levels. *California Fish and Game* 71: 110-113.
11. Hinch, S.G. and N.C. Collins. 1993. Relationships of littoral fish abundance to water chemistry and macrophyte variables in central Ontario lakes. *Can. J. Fish. Aquat. Sci.* 50: 1870-1878.
12. <http://elib.cs.Berkeley.edu/kopec/tr9/html/sp-bluegill.html>
13. <http://imc.lisd.k12.mi.us/bluegill.html>
14. <http://members.surfsouth.com/~randall/fishing/bluegill.html>
15. Johnson, D.L., R.A. Beaumier and W.E. Lynch Jr. 1988. Selection of habitat structure interstice size by bluegills and largemouth bass in ponds. *Transactions of the American Fisheries Society* 117: 171-179.
16. Konkle, B.R., N.C. Collins, and R.L. Baker. 1990. Use of artificial substrates to estimate prey resources available to a visually feeding benthivorous fish. *Can. J. Fish. Aquat. Sci.* 47: 789-793.
17. Li, K.T., J.K. Wetterer, and N.G. Hairston Jr. 1985. Fish size, visual resolution, and prey selectivity. *Ecology* 66: 1729-1735.
18. Miner, J.G. and R.A. Stein. 1993. Interactive influence of turbidity and light on larval bluegill (*Lepomis macrochirus*) foraging. *Can. J. Fish. Aquat. Sci.* 50: 781-788.
19. Mittelbach, G.G. 1984. Predation and resource partitioning in two sunfishes (Centrarchidae). *Ecology* 65: 499-513.
20. Mittelbach, G.G. and C.W. Osenberg. 1993. Stage-structured interactions in bluegill: consequences of adult resource variation. *Ecology* 74: 2381-2394.
21. Nibbelink, N.P. and S.R. Carpenter. 1998. Interlake variation in growth and size structure of bluegill (*Lepomis macrochirus*): inverse analysis of an individual-based model. *Can. J. Fish. Aquat. Sci.* 55: 387-396.
22. Nowlin, W.H., and R.W. Drenner. 2000. Context-dependent effects of bluegill in experimental mesocosm communities. *Oecologia* 122: 421-426.

23. Osenberg, C.W., G.G. Mittelbach, and P.C. Wainwright. 1992. Two-stage life histories in fish: the interaction between juvenile competition and adult performance. *Ecology* 73: 255-267.
24. Partridge, D.G. and D.R. DeVries. 1999. Regulation of Growth and Mortality in Larval Bluegills: Implications for Juvenile Recruitment. *Transactions of the American Fisheries Society* 128: 625-638.
25. Pierce, C.L., K.A. Musgrove, J. Ritterpusch, and N.E. Carl. 1987. Littoral invertebrate abundance in bluegill spawning colonies and undisturbed areas of a small pond. *Can. J. Zool.* 65: 2066-2071.
26. Scott, W.B. and E.J. Crossman. 1973. *Freshwater Fishes of Canada*. Bulletin 184. Fisheries Research Board of Canada. Ottawa, Ontario.
27. Taylor, B.E., J.M. Aho, D.L. Mahoney, and R.A. Estes. 1991. Population dynamics and food habits of bluegill (*Lepomis macrochirus*) in a thermally stressed reservoir. *Can. J. Fish. Aquat. Sci.* 48: 768-775.
28. Walton, W.E., N.G. Hairston Jr., and J.K. Wetterer. 1992. Growth-related constraints on diet selection by sunfish. *Ecology* 73: 429-437.
29. Werner, E.E., G.G. Mittelbach, D.J. Hall, and J.F. Gilliam. 1983. Experimental tests of optimal habitat use in fish: the role of relative habitat profitability. *Ecology* 64: 1525-1539.
30. Wever, M.J., J.J. Magnuson, and M.K. Clayton. 1997. Distribution of littoral fishes in structurally complex macrophytes. *Can. J. Fish. Aquat. Sci.* 54: 2277-2289.
31. Wildhaber, M.L. and L.B. Crowder. 1990. Testing a bioenergetics-based habitat choice model: bluegill (*Lepomis macrochirus*) responses to food availability and temperature. *Can. J. Fish. Aquat. Sci.* 47: 1664-1671.
32. Wildhaber, M.L. and L.B. Crowder. 1995. Bluegill Sunfish (*Lepomis macrochirus*) Foraging Behavior under Temporally Varying Food Conditions. *Copeia* (4): 891-899.
33. Wilson, D.S., P.M. Muzzall, and T.J. Ehlinger. 1996. Parasites, Morphology, and Habitat Use in a Bluegill Sunfish (*Lepomis macrochirus*) Population. *Copeia* (2): 348-354.
34. www.calntisa.com/fish/blgil.htm
35. www.dnr.cornell.edu/sarep/fish/Centrarchidae/bluegill.html
36. www.dnr.state.wi.us/org/water/fhp/fish/3dblgill.htm
37. www.gf.state.az.us/frames/fishwild/sporfi_h.htm
38. www.museum.state.il.us/exhibits/symbols/fish.html
39. www.ohiokids.org/ohc/nature/animals/fish/nbluegill.html
40. www.rook.org/earl/bwca/nature/fish/lepomismac.html
41. www.state.sd.us/gfp/Fishing/CommonSDFishes/Bluegill.htm
42. www.umich.edu/~bio440/fishcapsules96/Lepomis.html

APPENDIX C

DATA AND CPUE FOR ANGLING

Appendix C: Angling catch and catch per unit effort (CPUE) data for sampling in 2001 by ONFC

Date	Location description	Site *	Species caught				CPUE			Bait & tackle
			SMB	YP	NSC	CP	Start time	Hours fished	No. of fishers	
8-May	Vaseux Lake - 1st oxbow (MT21)	AG7					11:15	1.5	3	spinners & spoons
16-May	Vaseux wildlife viewing park	AG4	1				7:30	2	5	worms, spinners, spoons
16-May	Vaseux Lake - Rock bluff	AG5	1				9:30	2	5	worms, spinners, spoons
16-May	Vaseux Lake - south end	AG6	3	1			11:00	1	5	worms, spinners, spoons
16-May	Okanagan River - VDS 1 & oxbows	AG8,9,10					13:00	1	3	worms, spinners
16-May	Okanagan River - VDS 1 & oxbows	AG8,9,10					14:00	1	5	worms, spinners
18-May	Osoyoos Lake - north end	AG11	1			3	9:00	8	2	spinners & spoons
19-May	VDS 1 to 3	AG8,10	3		8	3	7:00	4	3	spinners & spoons
19-May	VDS 1 to 3	AG8,10	2				7:00	4	2	spinners & spoons
21-May	VDS 1 to 3	AG8,10	1		3		15:00	4	2	spinners & spoons
7-Sep	Penticton Oxbows	AG1			1		9:00	5	2	roe and worms
22-Nov	Penticton Oxbows	AG1,2					9:50	1hr 10min	1	worms
22-Nov	Vaseux Lake - south end	AG6					13:00	0.5	1	worms

* Site numbers correspond with location identified on Figures 2 through 7

APPENDIX D

DATA AND CPUE FOR BEACH SEINING

Appendix D: Beach seining catch and catch per unit effort (CPUE) for sampling in 2001 by ONFC

Lake	Date	Site *	Location	Species Caught														CPUE				Comments	
				BCB	BKH	CAS	CP	RSC	LMB	NSC	PCC	PMB	SK	SMB	SU	YP	WF	UNK	No. of hauls	Net depth (m)	Net length (m)		mesh size (mm)
Okanagan	3-May-01	BS1	Trout Creek								1								5	1.5	10	3.5	Cobble/gravel/sand D: murky E: Algae
Okanagan	3-May-01	BS6	Hatchery			3													1	1.5	10	3.5	Mud and Algae
Okanagan	3-May-01	BS6	Peach Orchard Park																1	1.5	10	3.5	Cobble/boulder
Okanagan	3-May-01	BS2	North of Naramata					1		1	1								1	1.5	10	3.5	Hard Clay/silt/gravel
Okanagan	3-May-01	BS2	Bay South of Naramata															232	3	1.5	10	3.5	A - cobble,gravel,algae & weeds B - Cobble,boulder C - Sand and gravel
Okanagan	3-May-01	BS3	Pumphouse - East																1	1.5	10	3.5	Cobble,boulder
Okanagan	3-May-01	BS3	Due East of Trout Creek																1	1.5	10	3.5	Boulder
Okanagan	3-May-01	BS4	North Penticton on reserve																1	1.5	10	3.5	Silt and mud
Osoyoos	10-May-01	BS7	Mouth of Okanagan river			4							45			5			2	3	30	3,10,25	A - Shallow,weed and silt B - deep weeds and silt
Osoyoos	10-May-01	BS10	Whitesands										91				1		2	3	30	3,10,25	Sandy
Osoyoos	10-May-01	BS10	South of Whitesands										31			2			2	3	30	3,10,25	A - Sandy B - Sandy and shore vegetation
Osoyoos	10-May-01	BS11	Central Basin slough		7										1	13			1	3	30	3,10,25	murky - Milfold machine working
Osoyoos	10-May-01	BS12	Park beach													5			1	3	30	3,10,25	Cobble and Gravel
Osoyoos	10-May-01	BS13	West side of Central basin	1		2										4			1	3	30	3,10,25	
Okanagan	15-May-01	BS1	Trout Creek			39		6		2	8				5				3	3	30	3,10,25	A - Sand B & C - cobble and gravel
Okanagan	15-May-01	BS2	Bay North of Naramata																1	3	30	3,10,25	Cobble & boulder
Okanagan	15-May-01	BS2	North side of Naramata Cr.			1				2					2				1	3	30	3,10,25	A - Silt and gravel
Okanagan	15-May-01	BS2	Naramata park Bay			54				1	4							40	2	3	30	3,10,25	B -Gravel and cobble C - cobble & boulder
Okanagan	15-May-01	BS5	Pullout S. of Kickinee Park			19				4					1				1	3	30	3,10,25	

* Site numbers correspond with location identified on Figures 2 through 7

Lake	Date	Site *	Location	Species Caught															CPUE				Comments
				BCB	BKH	CAS	CP	RSC	LMB	NSC	PCC	PMB	SK	SMB	SU	YP	WF	UNK	No. of hauls	Net depth (m)	Net length (m)	mesh size (mm)	
Okanagan	28-Jun-01	BS1	West side of Trout mouth			4				3					2				1	3	30	3,10,25	
Okanagan	28-Jun-01	BS1	East side of Trout cr. mouth			7											17		1	3	30	3,10,25	
Okanagan	28-Jun-01	BS2	South of Naramata park			21		2		3							11		1	3	30	3,10,25	
Okanagan	28-Jun-01	BS2	Naramata park			1				1							1		1	3	30	3,10,25	
Okanagan	28-Jun-01	BS2	Naramata park			5		3		2							9		1	3	30	3,10,25	
Okanagan	28-Jun-01	BS2	Naramata creek - mouth			1											1		1	3	30	3,10,25	
Okanagan	28-Jun-01	BS5	South of Kickinee park			4				11									1	3	30	3,10,25	
Okanagan	28-Jun-01	BS5	South of Kickinee park			1		6											1	3	30	3,10,25	
Okanagan	28-Jun-01	BS4	North of Penticton reserve			22				8							3		1	3	30	3,10,25	Very muddy substrate
Osoyoos	29-Jun-01	BS13	West side of Central Basin			1			6			1				89			1	3	30	3,10,25	Mainly gravel, some gravel
Osoyoos	29-Jun-01	BS12	Park beach			2			2							1		43	1	3	30	3,10,25	Fines
Osoyoos	29-Jun-01	BS11	Central Basin slough	5		1	4			4	23	20				7			1	3	30	3,10,25	Mainly fines, some gravel
Osoyoos	29-Jun-01	BS7	right side of river mouth			1										1	34	19	1	3	30	3,10,25	Fines (sandy)
Osoyoos	29-Jun-01	BS8	between Oxbow & OK river			2											7	14	1	3	30	3,10,25	Fines (sandy)
Osoyoos	29-Jun-01	BS9	Rattlesnake			7											18	16	1	3	30	3,10,25	Fines (sandy)
Osoyoos	29-Jun-01	BS10	Whitesands						11								1	300+	1	3	30	3,10,25	took 3 samples poss. Graylings
Okanagan	25-Sep-01	BS1	Eastside of Trout cr. mouth			2				33								1	1	1.6	28	15	took 3 samples poss. Graylings
Okanagan	25-Sep-01	BS2	Naramata			4				45							1	3	1/3	1.6	28	15	
Okanagan	25-Sep-01	BS2	Naramata			3				23									2/3	1.6	28	15	
Okanagan	25-Sep-01	BS2	Naramata			3				3	31								3/3	1.6	28	15	
Okanagan	25-Sep-01	BS4	South of Pumphouse			1					37								1	1.6	28	15	took sample
Okanagan	25-Sep-01	BS5	North of pumphouse														2		1	1.6	28	15	fines
Osoyoos	9-Nov-01	BS9	S. Rattlesnake			8													1	3	30	3,10,25	fines
Osoyoos	9-Nov-01	BS10	Whitesands																1	3	30	3,10,25	fines
Osoyoos	9-Nov-01	BS11	Central Basin slough						1				1						1	3	30	3,10,25	fines/cobble
Osoyoos	9-Nov-01	BS12	Park beach			1			1					1					1	3	30	3,10,25	Fines/Muddy
Osoyoos	9-Nov-01	BS13	W.shore Central Basin						1							1			1	3	30	3,10,25	

* Site numbers correspond with location identified on Figures 2 through 7

APPENDIX E

DATA AND CPUE FOR ELECTROFISHING BOAT

Appendix E: Electrofishing catch and catch per unit effort (CPUE) data for sampling in 2001 by ONFC

Lake	Site *	Species Caught																		CPUE						Comments
		BCB	BGB	BKH	BB	CP	KO	LMB	NSC	PCC	PMB	RB	RSC	CAS	SMB	SU	SK	WF	YP	Date	Sec.	Volts	Amps	Duty cycle	Temp.	
Okanagan	EF-b#1									2						18		13		22-Apr-01	1925	500	6.2	55%		
Okanagan	EF-b#2				1				5	1			23	14		8		4		22-Apr-01	1800	500	6.5	55%		
Okanagan	EF-b#3					1			4	3			2	3		6		1		22-Apr-01	750	500	6.2	55%		
Okanagan	EF-b#4					2			1				5	5		9		4		22-Apr-01	1644	500	6.2	40%		
Skaha	EF-b #5					1			6	4				3	1	35		5		23-Apr-01	1800	500	6.0	45%	7.9	
Skaha	EF-b #6					2				1	1			3	5	15				23-Apr-01	1507	500	6.3	40%	7.1 - 7.6	
Skaha	EF-b #7													3	10	11		2		23-Apr-01	1350	500	6.1	40%	7.1	
Skaha	EF-b #8			21							18			1	67	5			5	23-Apr-01	1500	500	5.8	35%	7.1	
Osoyoos	EF-b #9					7		1	5							1	3	3	298	25-Apr-01	1200	500	3.1	20%	14.3	
Osoyoos	EF-b #10	1				10			4	1				1		2	9	5	115	25-Apr-01	1800	500	5.1	30-35%	14.7	
Osoyoos	EF-b #11					1								1	1	1	20		60	25-Apr-01	600	500	5.6	35%	10.5	
Osoyoos	EF-b #12								1								90		29	25-Apr-01	600	500	5.2	35%	10.0	
Okanagan	EF-b #1								9	14			5	1		25		5		3-Jun-01	2355	500	3.8	30%	13.8 - 14	
Okanagan	EF-b #2								3				6	2		6				3-Jun-01	1654	500	3.8	30%	13.8	
Okanagan	EF-b #3													1		7		2		3-Jun-01	600	500	4	30%	13.8	
Okanagan	EF-b #4								2	3			11	1		14				3-Jun-01	1252	500	4.2	30%	14.1	
Skaha	EF-b #5																			4-Jun-01						rain
Skaha	EF-b #6			1		3			1	5		1		1	9	12				4-Jun-01	1500	500	4.8	30 - 35%	14.9	
Skaha	EF-b #7					1	2		7	2				2	12	9				4-Jun-01	952	500	4.8	30%	14.9	
Skaha	EF-b #8									1	1				38	6				4-Jun-01	1496	500	4.8	35%	14.8	
Osoyoos	EF-b #9					3					1	1				2	5		26	6-Jun-01	1441	500	5.7 - 6.2	30 - 35%	16.8	
Osoyoos	EF-b #10					54					1	1			1	4			22	6-Jun-01	2091	500	6.3	30%	16.0	
Osoyoos	EF-b #11					1						1				1	1		8	6-Jun-01	1250	500	4.4 - 4.8	20%	16.4	
Osoyoos	EF-b #12														1	5			1	6-Jun-01	990	500	5.8	35%	17.5	

* Site numbers correspond with location identified on Figures 2 through 7

		Species Caught																			CPUE						
Lake	Site *	BCB	BGB	BKH	BB	CP	KO	LMB	NSC	PCC	PMB	RB	RSC	CAS	SMB	SU	SK	WF	YP	Date	Sec.	Volts	Amps	Duty cycle	Temp.	Comments	
Okanagan	EF-b #1								16	30			15	1		18		20		21-Aug-01	1690	500	6.0	25%	22.0		
Okanagan	EF-b #2					2			8	12			4	2		13				21-Aug-01	1030	500	6.0	25%	22.0		
Okanagan	EF-b #3								4	13			5	1		9		1		21-Aug-01	716	500	6.0	25%	22.0		
Okanagan	EF-b #4																			21-Aug-01						rain	
Skaha	EF-b #5																			22-Aug-01						rain	
Skaha	EF-b #6																			22-Aug-01						rain	
Skaha	EF-b #7																			22-Aug-01						rain	
Skaha	EF-b #8																			22-Aug-01						rain	
Osoyoos	EF-b #9	8				4		64			11			1	13	14		2	62	27-Aug-01	1735	500	5.5 - 6.0	20%	21.4		
Osoyoos	EF-b #10	1	1			9		16			8				4	4			58	27-Aug-01	1308	500	5.5 - 6.0	20%	21.4		
Osoyoos	EF-b #11																3			27-Aug-01	377	500	5.5 - 6.0	20%	20.7	adult SK stop sampling	
Osoyoos	EF-b #12																1			27-Aug-01						rain	
Okanagan	EF-b#1&2															5		14		14-Nov-01	754	500	4.6	35%	7.8		
Skaha	EF-b #5					1			18	1				4	3	12		10	2	14-Nov-01	1500	500	5.8	35%	8.9		
Skaha	EF-b #6					1									11	3			1	14-Nov-01	1131	500	5.7	35%	9.0		
Skaha	EF-b #7								2						5	1			1	14-Nov-01	770	500	5.8	35%	9.0		
Skaha	EF-b#8								1		24				161	3				14-Nov-01	1360	500	4.8	32%	9.0		
Osoyoos	EF-b#12																	2		15-Nov-01	616	500	5.8	30-35%	9.5		
Osoyoos	EF-b#12														1	2		1		15-Nov-01	642	500	5.8	30-35%	9.5		
Osoyoos	EF-b#13														1	8	2	20		15-Nov-01	2031	500	5.8	30-35%	9.8		
Osoyoos	EF-b#14															2	1	10		15-Nov-01	1854	500	6.0	30-35%	9.5		
Osoyoos	EF-b #15															4	1	17	1	15-Nov-01	930	500	5.8	30-35%	9.5		

* Site numbers correspond with location identified on Figures 2 through 7

APPENDIX F

DATA AND CPUE FOR GILLNETTING

Appendix F: Gillnetting catch and catch per unit effort (CPUE) data for sampling in 2001 by ONFC

Date 2000	Lake	Site *	Mesh size (cm)	Species caught				CPUE			
				CP	NSC	SK adult	SU	Depth of Lake at set	Time set	Time picked	Area Description
29-Aug	Osoyoos lake	GN1	5, 6.25, 7.5, 8.75			7		20m	11:30 PM	6:00	center of northbasin
29-Aug	Osoyoos lake	GN2	5, 6.25, 7.5, 8.75	1	3		1	4m	24:20:00	2:45	north east of rattlesnake point
Total number of fish				1	3	7	1				

* Site numbers correspond with location identified on Figures 2 through 7

APPENDIX G

DATA AND CPUE FOR MINNOW TRAPPING

Appendix G: Minnow trapping catch and catch per unit effort (CPUE) data for sampling in 2001 by ONFC

Site *	Location	Species caught						CPUE					Comments
		BKH	CAS	NSC	PMB	RSC	YP	Date set	Time set	No.of traps	Date picked	Time picked	
MT1	Okanagan Lake		6			1		1-May-01	16:37	4	2-May-01	9:13	
MT2	Okanagan Lake		9					1-May-01	9:49	4	2-May-01	10:20	
MT3	Okanagan Lake							1-May-01	9:27	4	2-May-01	10:05	
MT4	Okanagan Lake		2	1				1-May-01	9:00	4	2-May-01	9:50	
MT5	Okanagan Lake		1					1-May-01	8:45	5	2-May-01	9:40	
MT6	Penticton Channel		1					18-Apr-01	10:30	3	19-Apr-01	9:50	
MT7	Penticton Channel		21					18-Apr-01	10:50	3	19-Apr-01	10:05	
MT7A	Penticton Oxbows - Kinney Ave							18-Apr-01	11:10	3	19-Apr-01	10:15	Beetles
MT7B	Pen. Oxbow - Oxbow Rv resort			1				18-Apr-01	11:30	3	19-Apr-01	10:35	
MT8	Penticton channel		21					18-Apr-01	11:40	3	19-Apr-01	10:50	
MT9	Skaha Lake							1-May-01	12:10	4	2-May-01	12:20	
MT10	Skaha Lake	1	1					1-May-01	12:05	4	2-May-01	12:05	
MT11	Skaha Lake		4					1-May-01	11:49	4	2-May-01	11:55	
MT11A	Skaha Lake - North of 11							1-May-01	11:36	4	2-May-01	11:40	In Weedbed
MT12	Skaha Lake		1					1-May-01	11:21	4	2-May-01	11:28	
MT13	OK Falls Channel							18-Apr-01	12:05	3	19-Apr-01	11:10	
MT14	OK Falls Channel		5					18-Apr-01	12:15	3	19-Apr-01	11:15	
MT15	OK Falls Channel		3					18-Apr-01	12:20	3	19-Apr-01	11:20	1 trap opened
MT16	OK Falls Channel		6					18-Apr-01	12:35	3	19-Apr-01	11:30	
MT17	Vaseux Lake		4		1			18-Apr-01	13:00	6	19-Apr-01	11:50	
MT20	Vaseux Lake -island		1					8-May-01	10:35	4	9-May-01	9:50	
MT21	Vaseux lake outlet-1st Oxbow							8-May-01	11:10	4	9-May-01	10:15	
MT22	Vaseux lake outlet-2nd Oxbow							8-May-01	11:30	4	9-May-01	10:20	
MT23A	Okanagan River- Vincor sign		1					18-Apr-01	13:35	3	19-Apr-01	12:30	
MT24A	Okanagan River -Transect # 4		1					18-Apr-01	14:00	3	19-Apr-01	12:40	
MT24B	Okanagan River -Transect # 5							18-Apr-01	14:10	3	19-Apr-01	12:55	
MT25	Okanagan River							18-Apr-01	14:50	3	19-Apr-01	13:40	
MT26	Okanagan River						1	18-Apr-01	15:15	3	19-Apr-01	14:05	
MT27	Okanagan River							18-Apr-01	15:30	3	19-Apr-01	14:15	
MT28	Okanagan Rv @end of dike							18-Apr-01	16:00	3	19-Apr-01	14:45	
MT28A	Osoyoos Lake- West Oxbow							18-Apr-01	15:40	3	19-Apr-01	14:30	
MT28B	Osoyoos Lake- East Oxbow							18-Apr-01	16:15	3	19-Apr-01	15:00	
MT29	Osoyoos Lake							1-May-01	14:11	4	2-May-01	14:00	
MT30A	Osoyoos Lake- northeast Bay		1				5	1-May-01	14:25	4	2-May-02	14:10	
MT31	Osoyoos Lake-Inkaneep Creek		1					1-May-01	14:35	4	2-May-02	14:20	
MT32A	Osoyoos Lake- Rattlesnake Pt		1					1-May-01	14:48	4	2-May-01	14:30	
MT33A	Osoyoos Lake - Whitesands		1					1-May-01	15:02	4	2-May-01	14:40	

* Site numbers correspond with location identified on Figures 2 through 7

Site *	Location	Species caught											CPUE					Comments
		BKH	CAS	CP	LMB	NSC	PMB	RSC	SMB	SU	YP	UNK	Date set	Time set	No.of traps	Date picked	time picked	
MT1	Okanagan Lake		3			2		2					24-Jul-01	17:30	4	25-Jul-01	16:20	baited with roe
MT2	Okanagan Lake		9										24-Jul-01	17:20	4	25-Jul-01	16:45	baited with roe
MT3	Okanagan Lake					1							24-Jul-01	17:10	4	25-Jul-01	15:30	baited with roe
MT4	Okanagan Lake							1	4				24-Jul-01	16:50	4	25-Jul-01	15:05	baited with roe
MT5	Okanagan Lake		1										24-Jul-01	16:40	4	25-Jul-01	14:45	baited with roe
MT9	Skaha Lake										1		24-Jul-01	15:15	4	25-Jul-01	13:40	baited with roe
MT10	Skaha Lake		2								1		24-Jul-01	15:00	4	25-Jul-01	13:15	baited with roe
MT11	Skaha Lake		1										24-Jul-01	14:45	4	25-Jul-01	13:00	baited with roe
MT12	Skaha Lake											2	24-Jul-01	14:30	4	25-Jul-01	12:45	baited with roe
MT13	OK Falls channel			156					2				26-Jul-01	11:55	4	27-Jul-01	11:30	baited with sardines
MT14	OK Falls channel		2										26-Jul-01	12:05	4	27-Jul-01	11:50	baited with sardines
MT15	OK Falls channel		3										26-Jul-01	12:18	2	27-Jul-01	12:07	baited with sardines
MT16	OK Falls channel		2							1			26-Jul-01	12:28	4	27-Jul-01	12:21	baited with sardines
MT17	Vaseux wildlife view		1		14		24		4				12-Sep-01	9:25	10	13-Sep-01	10:10	baited with sardines
MT20	Vaseux Island						1						12-Sep-01	10:30	4	13-Sep-01	11:30	baited with sardines
MT21	Vaseux oxbow 1								2		2		12-Sep-01	10:30	4	13-Sep-01	12:05	baited with sardines
MT22	Vaseux oxbow 2						5						12-Sep-01	10:40	4	13-Sep-01	12:20	baited with sardines
MT23A	Okanagan Rv. Beaver dam												26-Jul-01	11:25	3	27-Jul-01	15:20	baited with sardines
MT24C	Okanagan Rv. @transect 6												26-Jul-01	11:02	3	27-Jul-01	15:00	baited with sardines
MT25A	Okanagan River								3				26-Jul-01	10:15	3	27-Jul-01	14:40	baited with sardines
MT26	Okanagan River												26-Jul-01	10:00	3	27-Jul-01	14:20	baited with sardines
MT27	Okanagan River												26-Jul-01	9:42	4	27-Jul-01	14:04	baited with sardines
MT28	Okanagan River												26-Jul-01	9:05	4	27-Jul-01	13:37	baited with sardines
MT28B	Okanagan River	2			1				10				26-Jul-01	9:25	3	27-Jul-01	13:47	baited with sardines
MT29	Osoyoos Lake										1		24-Jul-01	10:25	4	25-Jul-01	10:05	baited with sardines
MT30	Osoyoos Lake												24-Jul-01	10:40	4	25-Jul-01	10:20	baited with sardines
MT31	Osoyoos Lake												24-Jul-01	11:00	4	25-Jul-01	10:30	baited with sardines
MT32	Osoyoos Lake												24-Jul-01	11:30	4	25-Jul-01	10:40	baited with sardines

* Site numbers correspond with location identified on Figures 2 through 7

Site *	Location	Species caught											CPUE					Comments
		BKH	CAS	CP	KO	LMB	NSC	RB	RSC	SMB	SU	YP	Date set	Time set	No.of traps	Date picked	Time picked	
MT1	Okanagan Lake		2						2				6-Nov-01	14:05	4	7-Nov-01	12:45	
MT2	Okanagan Lake		2										6-Nov-01	14:10	4	7-Nov-01	14:00	
MT3	Okanagan Lake		1				2						6-Nov-01	14:20	4	7-Nov-01	13:50	
MT4	Okanagan Lake		2						1				6-Nov-01	13:56	4	7-Nov-01	13:33	
MT5	Okanagan Lake		3						1				6-Nov-01	13:43	4	7-Nov-01	13:20	
MT6	Inlet Pen. Cr.		12				1						22-Nov-01	10:10	4	23-Nov-01	2:41	
MT7A	Oxbow near Kinney St.	4		1			9		2				22-Nov-01	9:50	4	23-Nov-01	1:50	
MT7B	Oxbow near Skaha		12							1			22-Nov-01	10:45	4	23-Nov-01	2:03	
MT7	Gr. Mtn. Bridge		4						2				22-Nov-01	10:35	4	23-Nov-01	2:23	
MT9	Skaha Lake		12										6-Nov-01	11:50	4	7-Nov-01	11:18	
MT10	Skaha Lake		6										6-Nov-01	12:28	4	7-Nov-01	11:45	
MT11	Skaha Lake												6-Nov-01	12:15	4	7-Nov-01	11:39	No Fish
MT12	Skaha Lake		1										6-Nov-01	12:05	4	7-Nov-01	11:27	
MT13	OK Falls channel		2										22-Nov-01	11:30	4	23-Nov-01	1:00	
MT14	OK Falls channel		14										22-Nov-01	11:35	4	23-Nov-01	1:10	
MT15	OK Falls channel		10							1			22-Nov-01	11:40	4	23-Nov-01	1:16	
MT16	OK Falls channel		5		1				1				22-Nov-01	11:50	4	23-Nov-01	1:25	
MT17	Vaseux wildlife view	1	4			2						1	22-Nov-01	12:30	4	23-Nov-01	11:30	
MT20	Vaseux Island												22-Nov-01	1:00	4	23-Nov-01	11:30	No Fish
MT21	Vaseux oxbow 1		2										22-Nov-01	1:10	4	23-Nov-01	12:00	
MT22	Vaseux oxbow 2												22-Nov-01	1:20	3	23-Nov-01	12:20	
MT23A	Okanagan Rv. Beaver dam																	
MT24A	Okanagan Rv. @transect 4		2					1					22-Nov-01	2:20	3	23-Nov-01	11:00	
MT25A	Okanagan River																	
MT26	Okanagan River																	
MT27	Okanagan River												22-Nov-01	2:20	3	23-Nov-01	10:00	
MT28	Okanagan River																	
MT28B	Okanagan River	1				1							22-Nov-01	2:30	3	23-Nov-01	9:30	
MT29	Osoyoos Lake												06-Nov_01	8:45	4	7-Nov-01	9:35	No Fish
MT30	Osoyoos Lake		6										6-Nov-01	9:30	4	7-Nov-01	9:43	
MT31	Osoyoos Lake												6-Nov-01	10:00	4	7-Nov-01	9:52	No Fish
MT32	Osoyoos Lake												6-Nov-01	10:10	4	7-Nov-01	10:06	No Fish

* Site numbers correspond with location identified on Figures 2 through 7

APPENDIX H

DATA AND CPUE FOR TRAP NETTING

Appendix H: Trap netting catch and catch per unit effort (CPUE) data for sampling in 2001 by ONFC

Area	Site *	Species caught					CPUE				Crew
		BKH	LMB	PMB	YP	Other	Net Set	Net Checked	Net Picked	Depth set	
Vaseux lake	TN1 - northwest side of Vaseux lake	1	2		5		July 24 4:00	July 25 2:30	July 26 10:30	2.5m	H.Wright, S.Lawrence, K.Long, H.Alex
Vaseux lake	TN2 - At outlet of Vaseux Lake on the west side	1	9	9	7	3 painted turtles	Sept 12 11:45am	Sept 13 12:00	Sept 14 10:00	3 to 4 m	K.Long, A.Snow, D.Alex, H.Alex

* Site numbers correspond with location identified on Figures 2 through 7

APPENDIX I
SPECIES CODES

The following species codes were used in the tables listing the species inventoried in the Okanagan Basin. The codes are based on Fisheries Information Summary System (FISS) BC fish species codes.

Species Code	Common name	Scientific name
BB	burbot	<i>Lota lota</i>
BCB	black crappie	<i>Pomoxis nigromaculatus</i>
BH	bullhead, catfish; general	<i>Ameiurus</i> spp.
BKH	black bullhead	<i>Ameiurus melas</i> (formerly <i>Ictalurus melas</i>)
BGB*	bluegill	<i>Lepomis macrochirus</i> (* no FISS species code)
BNH	brown bullhead	<i>Ameiurus nebulosus</i> (formerly <i>Ictalurus nebulosus</i>)
BS	bass, sunfish; general	<i>Micropterus</i> spp., <i>Lepomis</i> spp., <i>Pomoxis</i> spp.
BSU	bridgelip sucker	<i>Catostomus columbianus</i>
CAS	prickly sculpin	<i>Cottus asper</i>
CBC	chub; general	
CC	sculpin; general	primarily <i>Cottus</i> spp.
CCG	slimy sculpin	<i>Cottus cognatus</i>
CMC	chiselmouth	<i>Acrochellus alutaceus</i>
CP	carp	<i>Cyprinus carpio</i>
CSU	largescale sucker	<i>Catostomus macrocheilus</i>
DC	dace; general	<i>Rhinichthys</i> spp., <i>Phoxinus</i> spp.
EB	eastern brook trout	<i>Salvelinus fontinalis</i>
GC	goldfish	<i>Carassius auratus</i>
KO	kokanee	<i>Oncorhynchus nerka</i>
LDC	leopard dace	<i>Rhinichthys falcatus</i>
LMB	largemouth bass	<i>Micropterus salmoides</i>
LNC	longnose dace	<i>Rhinichthys cataractae</i>
LSU	longnose sucker	<i>Catostomus catostomus</i>
LT	lake trout	<i>Salvelinus namaycush</i>
LW	lake whitefish	<i>Coregonus clupeaformis</i>
MW	mountian whitefish	<i>Prosopium williamsoni</i>
NSC	northern pike minnow (formerly squawfish)	<i>Ptycheilus oregonensis</i>
PCC	peamouth chub	<i>Mylocheilus caurinus</i>
PMB	pumpkinseed, sunfish	<i>Lepomis gibbosus</i>
PW	pygmy whitefish	<i>Prosopium coulteri</i>
RB	rainbow trout, (formerly Kamloops trout)	<i>Oncorhynchus mykiss</i> (formerly <i>Salmo gairdneri</i>)
RSC	redside shiner	<i>Richardsonius balteatus</i>
SK	sockeye salmon	<i>Oncorhynchus nerka</i>
SMB	smallmouth bass	<i>Micropterus dolomieu</i>
SP	not identified	
ST	steelhead (summer run)	<i>Oncorhynchus mykiss</i>
SU	sucker; general	<i>Catostomus</i> spp.
TC	tench	<i>Tinca tinca</i>
WF	whitefish; general	<i>Prosopium</i> spp., <i>Coregonus</i> spp., <i>Stenodus</i> spp.
WP	walleye	<i>Stizostedion vitreum</i>
YP	yellow perch	<i>Perca flavescens</i>

FINAL

OBJECTIVE 2
Task B1

Results of sockeye smolt predator sampling
in the forebay and tailrace of Zosel Dam

YEAR 2 of 3

Submitted to:
Colville Confederated Tribes

Submitted by:
Chris Fisher

Results of sockeye smolt predator sampling in the forebay and tailrace of Zosel Dam

This field sampling was a part of the study to evaluate an experimental re-introduction of sockeye salmon (*Oncorhynchus mykiss*) into Skaha Lake (Bonneville Power Administration #20124). Historical records indicate that sockeye salmon once inhabited a series of chain lakes (Osoyoos, Vaseaux, Skaha, Okanagan), located in the upper region of the basin (Fryer 1995). However, the extent of sockeye salmon has been substantially reduced by impassable dams at Okanagan Lake (1915), Palmer Lake (1916), Vaseaux Lake (1921), replaced by McIntyre Dam (1954)). The current Okanagan sockeye salmon population is limited to rearing in the north end of the basin of Lake Osoyoos.

As part of the study one objective was to develop a life-cycle model (objective 4) to predict production, survival and returning adults if reintroduction occurred. To provide a better estimate of smolt survival, predator sampling occurred during suspected peak outmigration during the May of 2001. Fish collection was targeted towards known or potential predators of sockeye smolts including, northern pike minnow (*Ptychocheilus oregonensis*), smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*), adult yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*).

ELECTRO-FISHING

Sampling was conducted at the forebay and tailrace of Zosel Dam. Initially an electro-fishing boat was to be used however, due to extremely low flow conditions, access to the tailrace was not possible. Thus, this area was not sampled using electro-fishing techniques.

The forebay area was sampled on May 9th and 10th. On May 9th the forebay was sampled for approximately 20 minutes upriver of the Cherry Street bridge in Oroville, Washington. No predators were collected in this area. The most abundant species were largescale sucker (*Catostomus macrocheilus*) and sockeye salmon (smolt).

On May 10th the forebay proper was sampled for approximately 1 hour and 50 minutes. Sampling began at approximately 9:30 a.m. approximately ¼ mile upriver. Most abundant species were sockeye salmon (smolt), largescale sucker, peamouth (*Mylocheilus caurinus*), mountain whitefish (*Prosopium williamsoni*), northern pike minnow and smallmouth bass.

A lower reach, approximately ½ mile downstream of Zosel Dam, was sampled on May 9th. This reach extended approximately 1/8th mile upstream and 1/4th mile downstream from Hwy 97 bridge, south of Oroville, Washington. Total electro-fishing time was one hour. Most abundant species collected were mountain

whitefish and largescale sucker. Other species collected during the sampling period were common carp (*Cyprinus carpio*) and tench (*Tinca tinca*). Upon capture predatory fish were immediately subdued to reduce the possibility of regurgitation. Gut contents were examined via dissection.

Seven smallmouth bass and seven northern pike minnow were collected over the 2-day sampling period (Table 1). Of the 7 smallmouth bass 6 of 7 contained fish. One of the six smallmouth contained a fish that was identified as a salmonid and was of similar size as sockeye smolts. Other fish found in the stomach of smallmouth bass, although unidentifiable, were of similar size as Chinook salmon fry (40 – 55 mm). No fish or fish parts were found in the stomachs of the five yellow perch (total length > 6"0) collected. None of the collected northern pike minnow contained fish.

Table 1. Stomach contents of selected species from electrofishing sampling in forebay and tailrace of Zosel Dam during May 9th & 10th, 2001. (nd = no data collected).

Species	Length (mm)	Weight (grams)	Stomach contents
Smallmouth bass	281	309	1 fish - fry
Smallmouth bass	325	525	2 fish - fry
Smallmouth bass	310	421	3 fish - fry
Smallmouth bass	347	630	3 fish – 2 fry, 1 ~ 40 mm
Smallmouth bass	433	Nd	2 fish – unidentified, possibly salmonids
Smallmouth bass	308	321	2 fish - unidentified
Tench	379	Nd	Did not sample
Northern Pike minnow	430	Nd	Empty
Northern Pike minnow	362	Nd	Empty
Northern Pike minnow	423	Nd	Empty
Northern Pike minnow	422	Nd	Empty
Northern Pike minnow	362	Nd	Empty
Yellow perch	197	Nd	Snails, macro-invertebrates
Yellow perch	199	Nd	Snails, macro-invertebrates
Yellow perch	190	Nd	Vegetation
Yellow perch	198	Nd	Vegetation, macro-invertebrates
Yellow perch	189	Nd	Empty

ANGLING

As mentioned earlier, low flow conditions prevented access to the tailrace with the electro-fishing boat. An alternative technique to sample the tailrace was angling. Angling was conducted during evening hours (~ 6:00 p.m. to 10:00 p.m.) on May 11th and May 25th. Angling effort was approximately 25 hours (May 11th, 10 hours; May 25th 15 hours). Angling was conducted from the shore or the structure of Zosel Dam. Upon capture, predatory fish were subdued and stomach contents examined. Most common species caught were northern pike

minnow and smallmouth bass. Other species that were caught include peamouth and rainbow trout (*Oncorhynchus mykiss*). Nine smallmouth bass were collected. Four smallmouth bass contained fish, four were empty and 1 was not examined because it was considered too small (~ 200 mm) (Table 2). Of the four smallmouth bass that contained fish, one (156 mm TL) was positively identified as a sockeye smolt (Figure1). The gut contents of one smallmouth bass contained fish vertebrae with a total length of 80 mm. One smallmouth bass contained an unidentifiable fish approximately 50 mm and another bass



Figure 1. Smallmouth bass caught by angling in the tailrace of Zosel Dam, contained sockeye smolt.

contained an unidentifiable fish. Six of the eleven northern pike minnow caught contained fish. The gut content of one northern pike minnow was identified as a sockeye smolt (TL 142 mm). Three northern pike minnow contained unidentifiable fish parts. Two other northern pike minnow contained fish that were identified as juvenile yellow perch.

Table 2. Stomach contents of selected species collected by angling in the forebay and tailrace of Zosel Dam during May 11th & 25th, 2001. (nd = no data collected).

Species	Length (mm)	Stomach contents
Smallmouth bass	325	Empty
Smallmouth bass	336	Empty
Smallmouth bass	225	1 fish – (TL 50 mm)
Smallmouth bass	471	1 fish – identified smolt (TL 156 mm)
Smallmouth bass	373	1 fish – unidentified, incomplete vertebrae (TL – 80 mm)
Smallmouth bass	377	Empty
Smallmouth bass	334	fish – incomplete, unidentifiable
Smallmouth bass	412	Empty
Northern Pike minnow	426	Empty
Northern Pike minnow	372	Fish – incomplete, unidentifiable
Northern Pike minnow	534	Empty
Northern Pike minnow	531	Empty
Northern Pike minnow	440	Fish – incomplete, unidentifiable
Northern Pike minnow	370	Empty
Northern Pike minnow	510	1 Fish – identified smolt (TL 142 mm)
Northern Pike minnow	480	Fish – incomplete, unidentifiable
Northern Pike minnow	422	Empty
Northern Pike minnow	415	Fish – incomplete, unidentifiable (possibly yellow perch (TL 61 mm)
Northern Pike minnow	358	Fish - 1 Yellow perch (TL 65 mm), incomplete, unidentifiable, (possibly yellow perch)

SUMMARY

A total of 38 piscivorous predators, 14 smallmouth bass, 16 northern pike minnow and 5 yellow perch were collected and stomachs examined. Smallmouth bass, collected by both electro-fishing and angling, had the greatest occurrence of fish in their diet (62.5%), with 1 (7.1%) of the smallmouth bass containing apositively identified sockeye smolts. Thirty-seven percent of the northern pike minnow contained fish in the gut, with one (6%) northern pike minnow containing a positively identified sockeye smolt. Two of the northern pike minnow contained yellow perch. None of the adult yellow perch examined contained fish or remnants of fish.

Fifty percent of the smallmouth bass and 54% of the northern pike minnow caught by angling contained fish. One would assume fish that have recently fed would not strike a lure and consequently be caught by angling. Therefore, the percent of mortality by piscivorous predation estimated from angling is likely an under representation of the actual mortality. Furthermore, several of the predators that were collected contained fish, however the contained fish could not be accurately identified due to decomposition and therefore could be juvenile sockeye or Chinook fry.

In conclusion, it is likely that the occurrence of sockeye smolts found in the smallmouth bass and northern pike minnow population in the Zosel Dam area is greater than 7% and 6%, respectively. A more vigorous and unbiased (non-angling) sampling effort is necessary to achieve a more accurate estimate of predation upon sockeye and other species of interest, such as Chinook salmon, at the forebay and tailrace of Zosel Dam.

LITERATURE CITED

Fryer, J. K. 1995. Columbia Basin Sockeye salmon: Causes of there past decline, factors contributing to their present low abundance and the future outlook. Ph. D. Thesis: University of Washington, Seattle.

FINAL

Evaluation of an Experimental Re- introduction of Sockeye Salmon into Skaha Lake

OBJECTIVE 3 Inventory of Existing Sockeye Habitat and Opportunities for Habitat Enhancement

Year 2 of 3

Submitted to: Chris Fisher
Colville Confederated Tribes

Prepared by:
Karilyn Long
Okanagan Nation
Fisheries Commission

April 2002

EXECUTIVE SUMMARY

This report is from work of YEAR 2, the second year of a three-year risk examination of re-introducing sockeye salmon past McIntyre Dam into Skaha Lake in the Okanagan River system of British Columbia. It builds on the recommendations made in 2000 (YEAR 1) that if passage is provided, reasonable opportunities to improve the spawning areas exist.

An inventory was conducted to determine the amount, location and quality of potential spawning habitat between McIntyre and Okanagan Lake Dams (i.e. beyond the current range of Okanagan sockeye). From Okanagan Lake outlet Dam to McIntyre Dam, less than 1% of the total habitat surveyed was high quality. At present the high quality sockeye spawning areas are between Osoyoos Lake and McIntyre Dam.

On October 18th, 2001, Chris Bull (Glenfir Resources), Kari Long, (Okanagan Nation Fisheries Commission), Bob Newbury (Newbury Hydraulics) and Howard Smith (Ed James Lake Forest Resources Ltd.) collaborated in an assessment of options for increasing sockeye salmon spawning opportunities in the Okanagan River between Osoyoos Lake and Okanagan Lake (see Figure 1). Conditions in the channel below the Okanagan Lake Dam (Reach A) were identified as the most promising for development. However, any Okanagan River channel site with sufficient water depth and velocity, though having inferior substrate, could be upgraded to a productive spawning area particularly if suitable gravel was provided. Reach C may have opportunities for establishing Chinook salmon in the vicinity of Okanagan Falls where substrate and velocities are probably within preference ranges. A wildlife reserve nearby might include areas where ponds could be developed as rearing facilities for chinook or coho salmon should these be considered for introduction in the future. Sockeye were spawning throughout Reaches G-F wherever suitable gravel occurred. The riffles were constructed during August 2001 in Reach H, and were utilized by modest numbers of sockeye October 2001.

Reintroduction of sockeye into Skaha Lake might, through the process of residualism, simply increase the existing kokanee population at the expense of anticipated seaward migrations of anadromous fish. Early appearing adult sockeye have been reported "bumping their noses" at Skaha Lake dam presumably seeking spawning opportunities farther upstream then eventually returning down river at least as far as Vaseux Lake. Their behavior at the dam may simply reflect a normal drive on the part of some members of the population to extend their range. However, it could also reflect a strong inherent urge to return to spawning grounds of ancestral populations, perhaps in Okanagan Lake or its tributaries.

More information is needed on the dynamics of the early run of Okanagan River sockeye. If these fish are remnants of an historic early run originating in the upper lake basins, they might be the best part of the stock for use in any reintroduction. When sockeye runs that have two or more components separated by time of migration, the earliest component migrates the farthest upstream. A number of factors influence the extent of upstream migration including travel distance, temperature regimes and food availability.

In any event information about the behavior of the early segment of the Okanagan River sockeye run, though sketchy, seems perfectly consistent with that of a relict population which, seeking cooler water and ancestral spawning grounds upstream, but deprived of both and finding ambient river temperatures rising intolerably, after a time gives up and returns downstream.

The existing moderate to highly utilized spawning reaches are in the steep Reaches F and G below Vaseaux Lake. Reach F is naturally braided and meandering. Reach G is channelized with a suitable gravel bed that is back flooded by Vertical Drop Structure 13 (VDS 13). Above McIntyre Dam, Reach C is similar to Reach G but in most years fish passage upstream into the reach is blocked by the dam. Reaches A, B and D are less steep allowing finer gravels to accumulate and these are typically used by kokanee. Sockeye successfully spawn in Reach G above VDS 13. Similar conditions may be created in Reach C as it has a similar slope position in relation to a lake. Spawning on the upstream side of the constructed riffles in Reach H occurs where suitable gravels have been added.

In most flow conditions, passage to the steeper Reach C is blocked by McIntyre dam. In addition, the Okanagan Falls dam blocks fish passage to the less steep Reaches A and B above Skaha Lake. Okanagan Falls dam has fish passage built into it however, stepped pool and riffle side channels may be constructed around the dam that would act as fishways.

ACKNOWLEDGEMENTS

The Okanagan Nation Fisheries Commission would like to thank Howard Smith (Ed James Lake Forest Resources Ltd.) for and Robert Newbury (Newbury Hydraulics) for their time and expert opinions. Thanks to Chris Bull (Glenfir Resources) for all you do.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
1.0 INTRODUCTION	1
1.1 Project Scope and Background	1
2.1 Study Area	1
2.0 METHODS	3
2.1 Inventory	3
2.1 Identification of rehabilitation opportunities	4
3.0 RESULTS.....	5
4.0 DISCUSSION.....	14
5.0 RECOMMENDATIONS AND ENHANCEMENT FEASIBILITY	16
5.1 Enhancement in Reach A.....	16
5.2 Enhancement in Reach C.....	18
5.3 Preliminary Cost Estimates	19
5.0 REFERENCES	20
Appendix A: Sockeye Spawning Habitat Quantity Survey	
Appendix B: Sockeye Spawning Habitat Quality Survey	
Appendix C: Sockeye Spawning Habitat Survey Summary	
Appendix D: Discussion of spawning areas enhancement and opportunities (H. Smith)	
Appendix E: Spawning Reaches and enhancement feasibility (R. Newbury)	
Appendix F: Resumes of R. Newbury and H. Smith	

LIST OF FIGURES AND TABLES

Figure 1. Overview of the study area.....	2
Figure 2. Reach A.....	6
Figure 3. Reach B.....	7
Figure 4. Reach C.....	8
Figure 5. Reach D.....	9
Figure 6. Reach E.....	10
Figure 7. Reach F.....	11
Figure 8. Reach G.....	12
Figure 9. Reach H.....	13
Figure 10. Okanagan River long profile.....	17
Table 1. Spawning habitat parameters.....	4
Table 2. Summarizing the amount of sockeye spawning areas for each reach...5	
Table 3. Opportunities for sockeye spawning habitat rehabilitation.....	14
Table 4. Reach lengths and slopes.....	16
Table 5. Reach A – spawning enhancement works.....	19
Table 6. Reach C Spawning enhancement works.....	19
Photo 1. Collecting substrate	4
Photo 2. Okanagan Lake Outlet Dam.....	6
Photo 3. Typical Reach A habitat.....	6
Photo 4. Typical Reach B habitat.....	7
Photo 5. Skaha Lake outlet Dam.....	8
Photo 6. Typical Reach C habitat.....	8
Photo 7. Typical Reach D habitat.....	9
Photo 8. Typical Reach E habitat.....	10
Photo 9. McIntyre Dam looking upstream into the Intake Irrigation Flume.....	10
Photo 10. Typical Reach F habitat.....	11
Photo 11. Sockeye spawning in 2001 in Reach F (the natural section).....	11
Photo 12. Typical Reach G habitat.....	12
Photo 13. Vertical Drop Structure 13.....	12
Photo 14. Typical Reach H habitat.....	13
Photo 15. Outlet of Okanagan River into Osoyoos Lake.....	13
Photo 16. Concentrated fall below drop structure 14	18
Photo 17. The fall below drop structure 12	18

1.0 INTRODUCTION

1.1 Project Scope and Background

2001 is the second of a three-year assessment of the feasibility of re-introducing sockeye salmon past McIntyre Dam into Skaha Lake. This year's work (2001) builds on the recommendations made in the YEAR 1 report.

The YEAR 1 Assessment (Bull, 2000) concluded that there is little spawning area available either in Skaha Lake or in tributary streams upstream of McIntyre Dam. Bull recommended that if the run is extended past McIntyre Dam, spawning areas in the main river should be improved. This would first require feasibility studies.

The YEAR 2 Assessment includes an inventory of potential and current sockeye spawning areas. The region below McIntyre Dam was inspected to provide information on the physical characteristics of current sockeye spawning areas. This information was used in assessing the potential of areas located above McIntyre Dam within the Okanagan River main stem. Thereafter, an assessment of opportunities for sockeye habitat enhancement and development, and preliminary engineering feasibility assessment were completed.

1.2 Study Area

The study area above McIntyre Dam (Figure 1) consists of three sections and five reaches of the main stem of the Okanagan River:

- between Okanagan Lake and Skaha Lake (Reaches A & B),
- between Skaha Lake and Vaseux Lake (Reaches C & D) and,
- from the outlet of Vaseux Lake to McIntyre Dam (Reach E).

The study area below McIntyre Dam extends from McIntyre Dam to Osoyoos Lake through the last remaining natural section (Reach F) and the channelized river (Reaches G & H).

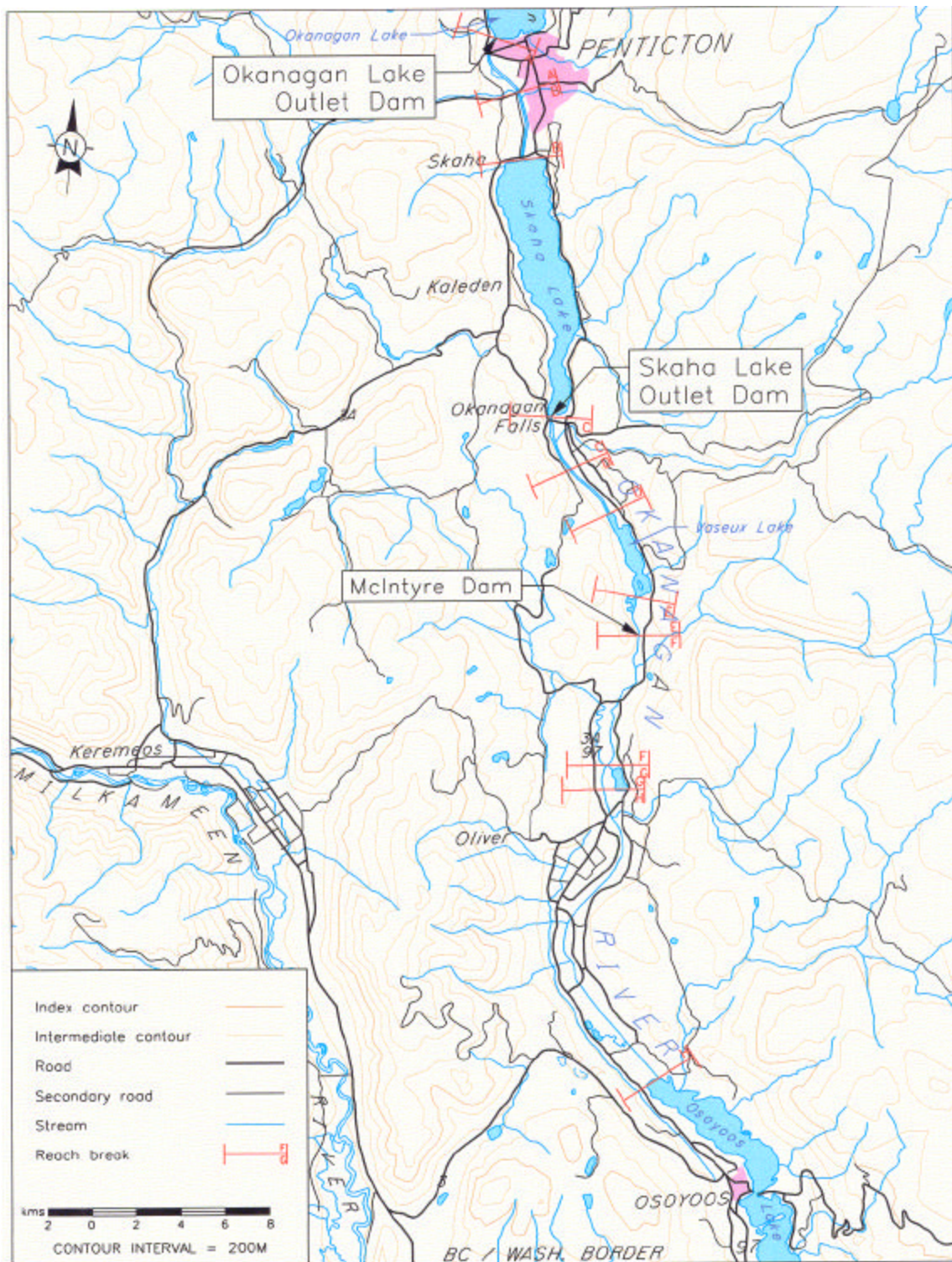


Figure 1. Overview of Study Area Above and Below McIntyre Dam

2.0 METHODS

2.1 Inventory

The objective of the habitat inventory was to determine the amount, location and quality of potential spawning habitat between McIntyre Dam and Okanagan Lake (i.e. above the current range of Okanagan sockeye). However, Department of Fisheries and Oceans (DFO) recommended expanding the study area to include the current spawning habitat (McIntyre Dam to Osoyoos Lake) as a base of comparison to see if upstream areas differ appreciably from the downstream areas where the fish now spawn successfully (K. Hyatt, Personal Communication).

The assessment methodology was developed by Glenfir Resources with input from Department of Fisheries and Oceans and based upon modified Provincial Fish Habitat Assessment Procedures (FHAP). The quantity and quality assessments were undertaken sequentially.

Habitat quantity assessments were completed May 28th to June 1st, 2001 by dividing the Okanagan River into reaches with each reach further divided into descriptive units; i.e. pools, riffles or glides. Each unit was mapped and photographed then subdivided into polygons based on substrate type (fines, gravel, cobble, boulder and bedrock), according to procedures of Johnson and Slaney (1996). Polygons thought to contain enough gravel to support spawners were more accurately mapped in the field and their areas were measured. Each polygon was entered on Okanagan River Channel maps (Schubert, 1980) with the UTM coordinates noted.

Quality ratings (either high, medium or low) were based on both measured parameters, (water depth, water velocity and substrate size) and visual criteria, (percent fines, uniformity of substrate size, presence of macrophytes and the likelihood of desiccation or scouring). Water depths were measured in centimeters, and velocities in metres/second using a Swaffer velocity flow metre. The median substrate was found by measuring 100 rocks from a grid superimposed on the polygon to be assessed (see Photo 1). Occurrence of fines was estimated as a percentage by area of all visible substrate materials. The relative uniformity of substrate size was determined by recording all substrate types (boulder, cobble, gravel and fines). Macrophytes were noted as either absent or as a percentage of the polygon area. Finally, the likelihood of past desiccation or scouring was estimated from occurrences of exposed substrates and eroded banks and each was delineated as either high, medium or low. The quality survey was undertaken June 19th to 28th 2001, when river flows were within the preferred spawning range.

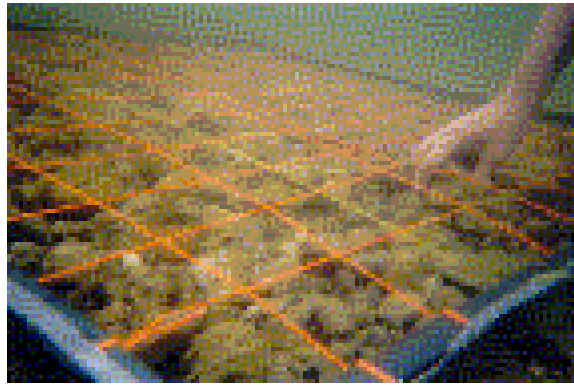


Photo 1. Collecting substrate

Ratings found in Table 1, are based on information from the Okanagan River Sockeye Spawning Habitat Assessment (Summit 2000).

Table 1. Spawning parameters

Spawning area suitability	Water depth (cm)	Water velocity (m/s)	Median substrate size (mm)	Percent fines
High	25 – 63	34-67	38-102	<30%
Medium	15 – 80	20-10	13-38	<30%
Low	<15	<10, >67	<13, >102	<=30%

2.2 Identification of rehabilitation opportunities

On October 18th, 2001, a working group consisting of Chris Bull (Glenfir Resources), Karilyn Long, (Okanagan Nation Fisheries Commission), Bob Newbury (Newbury Hydraulics) and Howard Smith (Ed James Lake Forest Resources Ltd.) collaborated in an assessment of options for increasing sockeye salmon spawning opportunities in the Okanagan River between Oliver and Penticton. The visit coincided with the peak of sockeye spawning. Two attractive areas for spawning enhancement and development are: Reach A (Okanagan Lake Outlet Dam to Green Mtn. Road); and Reach C (Skaha Lake Outlet Dam to VDS 14), which are consistent with results from the inventory.

3.0 RESULTS

An estimate of the amount of spawning area in each of high, medium and low utility areas above and below McIntyre Dam is given in Table 2. Tables showing results of both the Habitat Quantity Survey and Quality Survey are found in Appendix A, B and C respectively. The polygons in Table 2 are identified on the air photo composites found in Figures 2 through 9.

From Okanagan Lake Outlet Dam to McIntyre Dam, there are 63 m² of high quality, 7,058m² of medium and 1,265 m² of low quality for a total of 8,386 m² of spawning substrate. Polygons 5 and 12 were not considered viable spawning areas.

At present, sockeye spawn only between McIntyre Dam and Osoyoos Lake. There are 4,130 m² of high quality spawning habitat, 95,569 m² of medium quality spawning habitat and 5,059 m² of low quality habitat available to sockeye salmon for a total of 104,758 m². Polygon 14a was not considered viable spawning habitat.

Okanagan River from Okanagan Lake Outlet Dam to Osoyoos Lake has been divided into eight reaches (Reach A through H). Reaches A to E are located above McIntyre Dam and Reaches F to H are located below McIntyre Dam.

Table 2. Summarizing the amount of sockeye spawning areas for each reach

Reach	High Utility Areas	Medium Utility Areas	Low Utility Areas	Polygon Numbers
Area Between Okanagan Lake and McIntyre Dam				
A	63	6,955	0	1 – 8
B	0	0	0	-
C	0	103	1,230	9 – 12
D	0	0	35	13 – 14
E	0	0	0	-
Total	63	7,058	1,265	
Area Between McIntyre Dam and Osoyoos Lake				
F	4,130	14,965	3,742	13a, 14a & 15 - 38
G	0	74,736	0	39
H	0	5,868	1317	40 - 49
Total	4,130	95,569	5,059	



Figure 2. Reach A

REACH A

Reach length: 3.07km

Location: Okanagan Lake Outlet Dam to Green Mtn Road Bridge crossing



Photo 2. Okanagan Lake Outlet Dam

Characteristics: Channelized, dyked and rip rapped for its entire length. The main habitat type is essentially a river glide with cobbles and some gravel on the bottom. There is one 100m section of gravel which was trucked in for kokanee spawners. There is little riparian vegetation.



Photo 3. Typical Reach A habitat

Quality of substrate: Medium to low

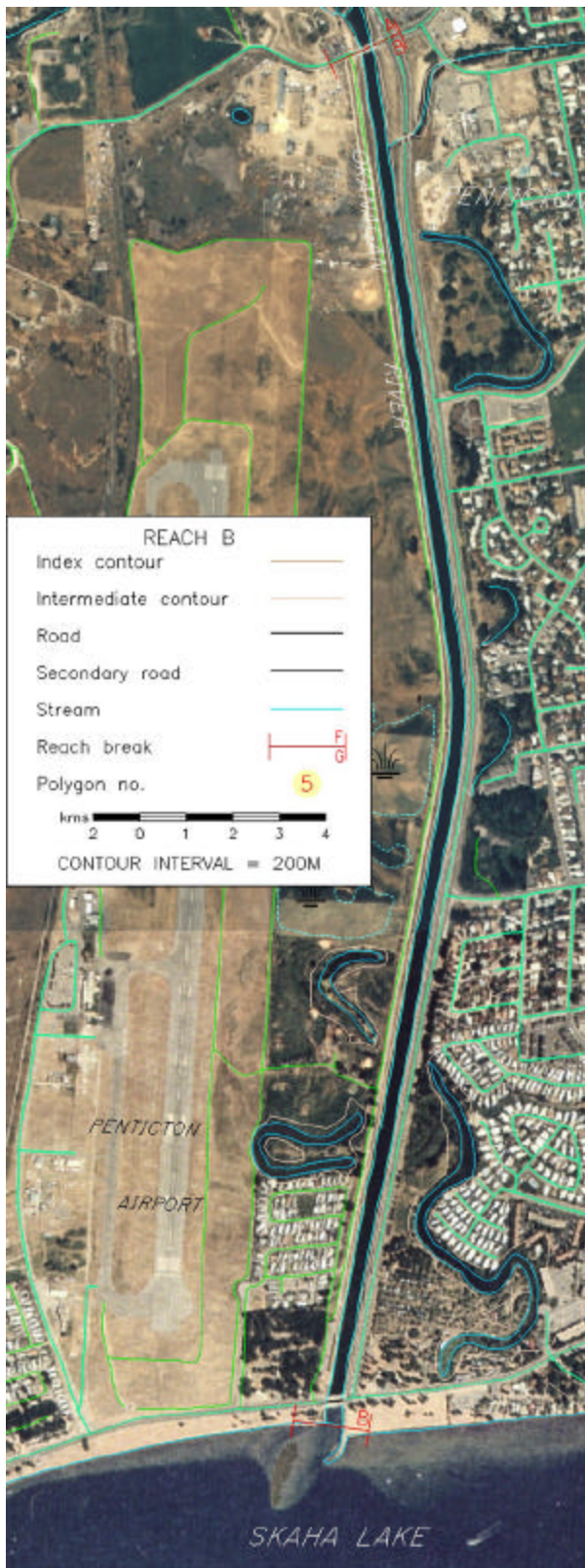


Figure 3. Reach B

REACH B

Reach length: 3.21 km

Location: Green Mtn Road Bridge crossing to Skaha Lake.

Characteristics: Channelized and rip rapped its entire length and has little riparian vegetation. The dominant habitat type is pool with fine substrate.



Photo 4. Typical Reach B habitat

Quality of substrate: Nil



Figure 4. Reach C

REACH C

Reach length: 2.49 km

Location: Skaha Lake outlet Dam (a.k.a OK Falls control Dam) to Vertical drop structure (VDS) 14



Photo 5. Skaha Lake outlet Dam

Characteristics: Channelized and rip rapped its entire length with little riparian vegetation. The dominant habitat type is glide with primarily gravels, cobbles.



Photo 6. Typical Reach C habitat

Quality of substrate: Medium - During 2000, returning sockeye migrated through McIntyre Dam and were observed spawning in Reach C.



Figure 5. Reach D

REACH D

Reach length: 2.74 km

Location: VDS 14 to Vaseux Lake

Characeristics: Channelized with rip rapped banks and sparse riparian vegetation throughout. The Canadian Wildlife Service maintains backwatered sloughs for waterfowl habitat along its west bank.



Photo 7. Typical Reach D habitat.

Quality of substrate: Nil



Figure 6. Reach E

REACH E

Reach length: 1.84 km

Location: Vaseux Lake to McIntyre Dam

Characteristics: Has two off-channel sloughs and natural riparian vegetation along its west bank. The east bank is agricultural land with sparse vegetation. The substrate is mainly fines with pool habitat.



Photo 8. Typical Reach E habitat, facing downstream with McIntyre Bluff in the background.

Quality of substrate: Nil

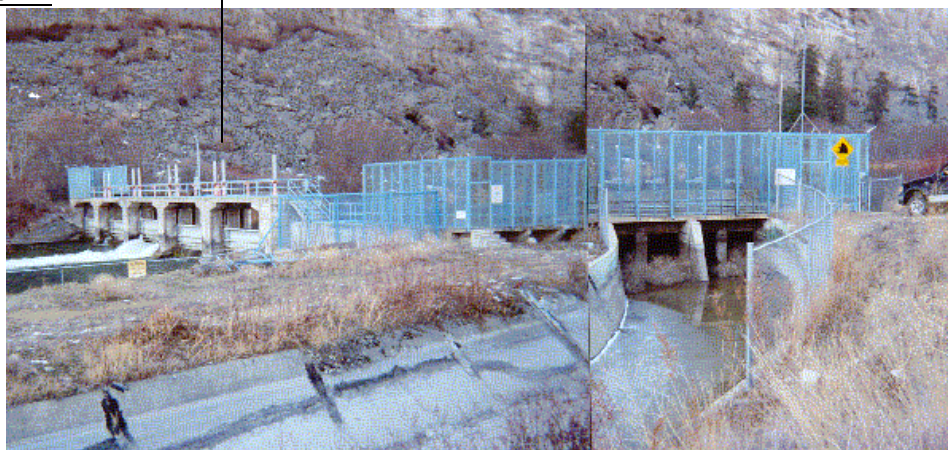


Photo 9. McIntyre Dam looking upstream into the Intake Irrigation Flume



Figure 7. Reach F

REACH F

Reach length: 5.95 km

Location: McIntyre Dam to upstream end of channelized section

Characteristics: Contains the only natural section of Okanagan River and is the main sockeye spawning habitat.



Photo 10. Typical Reach F habitat.

Quality of substrate: Medium to high.
Presently used by spawning sockeye.

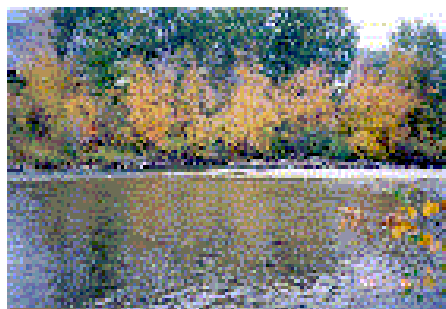


Photo 11. Sockeye spawning in 2001 in the natural section (Reach F)



REACH G

Reach length: 2.00 km

Location: Upstream end of channelized section to VDS 13

Characteristics: Channelized with natural banks and sparse riparian vegetation. This reach contains riffle and glide habitats with suitable gravel substrate.

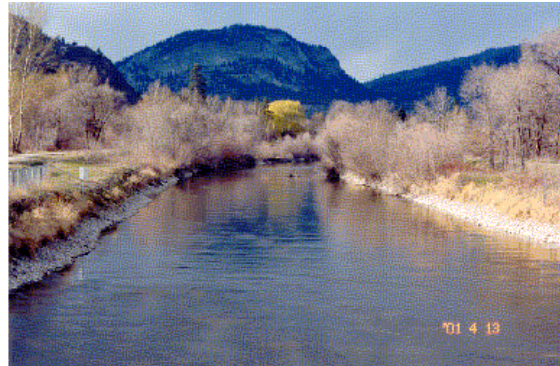


Photo 12. Typical Reach G habitat

Quality of substrate: Medium to high. Presently used by spawning sockeye.



Photo 13. Vertical Drop Structure 13

Figure 8. Reach G

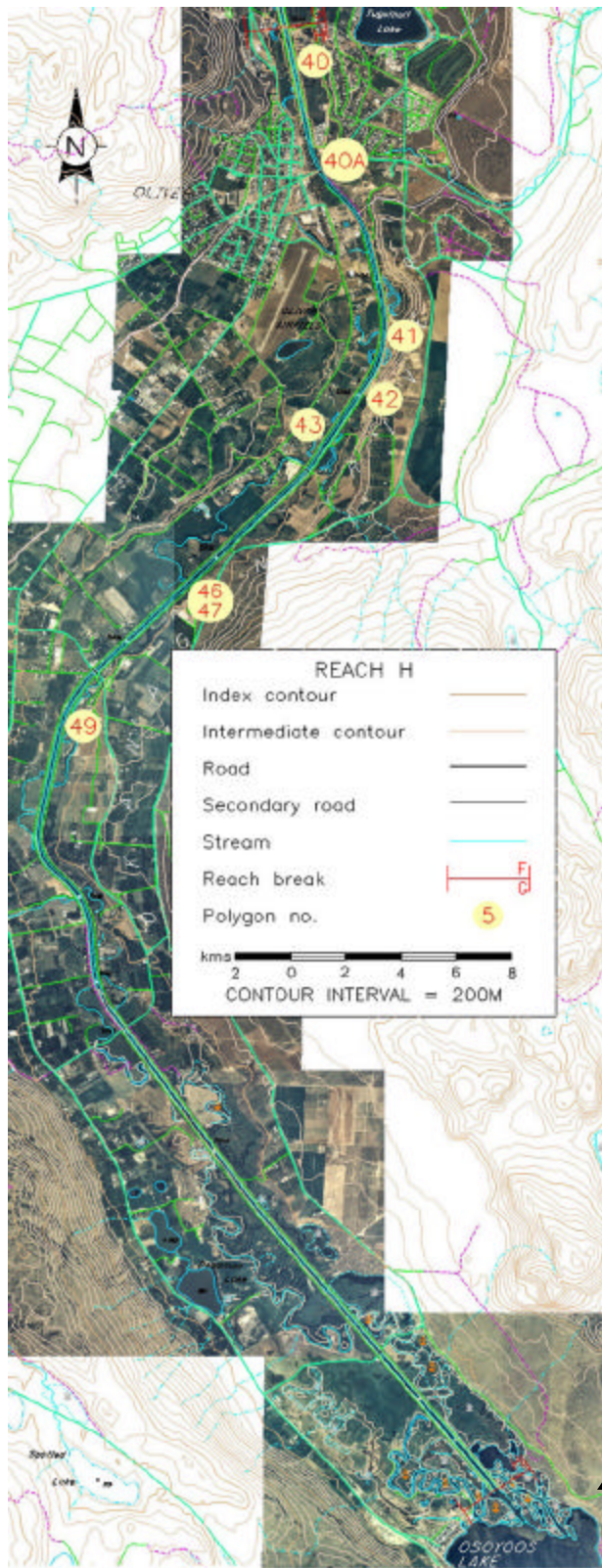


Figure 9. Reach H

REACH H

Reach length: 14.93 km

Location: VDS 13 to Osoyoos Lake

Characteristics: Channelized and riprapped banks with little riparian vegetation throughout. There are primarily pools and glides with mostly cobbles and fine materials in the substrate.



Photo 14. Typical Reach H habitat

Quality of substrate: Medium to low. Productive substrate limited to the upstream side of the Vertical Drop Structures.



Photo 15. Outlet of Okanagan River into Osoyoos Lake.

4.0 DISCUSSION

After review and discussion by the working group on Oct 18, several possible rehabilitation opportunities were identified (Table 3).

Table 3. Opportunities for sockeye spawning habitat rehabilitation

Reach	Location	Sockeye habitat rehabilitation opportunities
A	Below the Okanagan Lake Outlet Dam in Penticton	This could be an ideal location in which to experiment with variations in water depth and, patterns and sizes of introduced gravel. Kokanee spawning areas have been developed here and are used by kokanee during spawning. There may be an opportunity to increase velocity by constructing riffles with the introduction of suitable gravel.
C	Below Vertical Drop Structure 17	There may be opportunities for re-establishing Chinook salmon in the vicinity of OK Falls where substrate and velocities are within their tolerance ranges.
D	Lower Reach D including the flooded marsh area.	Sockeye spawning habitat is limited because of gradients < 1%. A wildlife reserve nearby might include areas where ponds could be developed as rearing facilities for chinook or coho salmon.
G	Upstream of VDS 13	Steep to moderate gradients caused by drop structures allow installation of effective sloped gravel beds with high potential for spawning success. Sockeye were spawning throughout reaches G-F wherever preferred-size gravel was present.
H	Riffles placed between VDS 11 and 12	During construction in August 2001, gravel was deposited in two of the four riffles. Sockeye spawned in modest numbers on the gravel patches. Initial observations indicate that additional gravel when associated with constructed riffles improves both quality and quantity of spawning areas.

Smith thought that based upon the limited observations of Oct 18, conditions in the channel below the Okanagan Lake Dam (Reach A) were the most promising for development. However, possibly any Okanagan River channel site with sufficient water depth and velocity could be upgraded to a productive spawning area by adding preferred size spawning gravel. The reasons for Reach A being the most promising for development are as follows:

- Gravel stability – minimum tendency to shift downstream in this area where flows are controlled.
- Controlled flow and substrate- because the age and size of Okanagan River sockeye vary little, spawning habitat improvements based on measured preference would meet the needs of the population.
- Low Siltation – it is unlikely that silt/fine sediment would be readily transported and deposited in this reach due to its proximity downstream of Okanagan Lake.

Smith also thought that factors such as residualism and homing instincts need to be considered if the reintroduction of sockeye to Skaha Lake is to proceed. For example reintroduction of sockeye into Skaha Lake might, through the process of residualism, increase the existing kokanee population at the expense of anticipate seaward migrations.

In the case of homing instincts, early appearing adult sockeye have been reported “bumping their noses” at Skaha Lake Outlet dam presumably seeking spawning opportunities farther upstream then eventually returning down river at least as far as Vaseux Lake. This may simply reflect a normal drive on the part of some members of the population to extend their range. However, it could also reflect a strong inherent urge to return to spawning grounds of ancestral populations, perhaps far above in Okanagan Lake or its tributaries. Commonly sockeye runs which have two or more components separated by time of migration, send their earliest fish farthest upstream. A number of factors influence this tendency, including travel distance, temperature regimes both en route and at destination, and during spawning and incubation, the timing of food (e.g. plankton blooms) essential for emergent fry in the spring also play a part.

In any event information about the behaviour of the early segment of the Okanagan River sockeye run, though sketchy, seems perfectly consistent with that of a relict population which, seeking cooler water and ancestral spawning grounds upstream, but deprived of both and finding ambient river temperatures rising intolerably, after a time gives up and returns downstream (Appendix D).

5.0 RECOMMENDATIONS AND ENHANCEMENT FEASIBILITY

Bob Newbury (Newbury Hydraulics) grouped together the eight reaches of Okanagan River into three reaches for analysis (Figure 10). For the three sections, lengths and slopes are represented in Table 4. His full report is in Appendix E.

Table 4. Reach lengths and slopes

Reaches	Location	Length (km)	Fall (m)	Slope (%)
E, F, G & H	Osoyoos Lake – Vaseux Lake	24	49	0.21
C & D	Vaseux Lake to Skaha Lake	4	10	0.25
A & B	Skaha Lake – Okanagan Lake	6	2.9	0.048

The existing moderate to highly utilized spawning reaches occur in the steep Reaches F and G between Vaseux Lake and Skaha Lake. Reach F is naturally braided and meandering. Reach G is channelized with a suitable gravel bed that is backflooded by Vertical Drop Structure 13 (VDS13).

Between Vaseux Lake and Skaha Lake, Reach C is similar to Reach G but in most years fish passage upstream into the reach is blocked by McIntyre Dam. Reach D has a milder slope and finer bed materials.

Between Skaha Lake and Okanagan Lake, Reaches A and B have much less slope than the downstream ones used for spawning. No vertical drop structures are required to control the gradient. Finer gravels have accumulated or been added to the channelized bed used by spawning kokanee. Fish passage to the reach is blocked by the Skaha Lake Outlet Dam as well as the McIntyre Dam.

5.1 Enhancement in Reach A

Five riffles and spawning platforms could be added to the upper end of this segment in Reach A by utilizing the fall created by the Okanagan Lake Outlet Dam. This would increase the local gradient to 0.17% and reduce the riffle spacing to 120m, approximately 6 times the channel base width. The total riffle would extend from 120m below the dam to approximately the Highway 97 (Green Mtn. Road) crossing.

The riffle and ramp design would have to be modified to accommodate tube and raft recreation by using rounded rock and a more carefully sculpted chute. There is some liability involved in changing the now uniform canal into 5 reaches with small drops that would require some steering and negotiation.

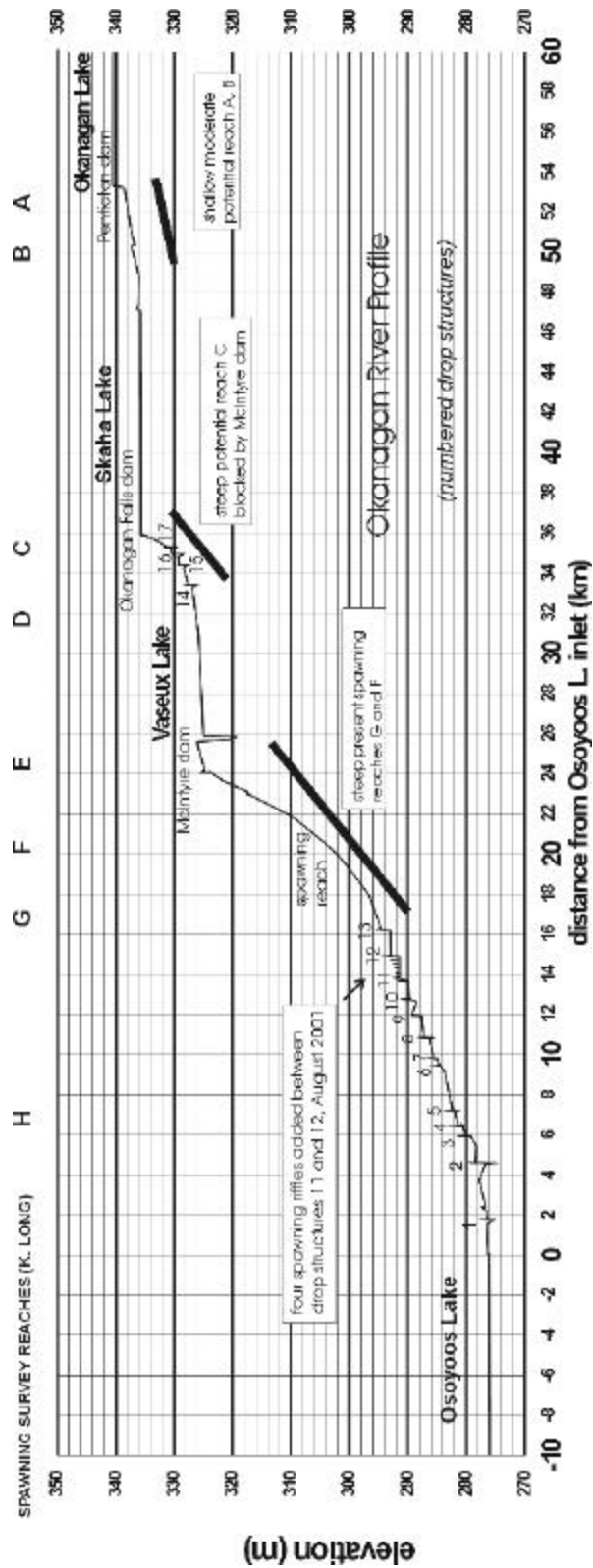


Figure 10: the Okanagan River long profile showing spawning reaches and spawning riffles added below drop structure 12 in August 2001.

5.2 Enhancement in Reach C

Sockeye successfully spawned in Reach G above Vertical Drop Structure 13 (VDS 13). These conditions may be created in Reach C as it has a similar slope and position just below a lake.

The options for spawning enhancement in Reach C are:

1. Excavation and Gravel Replacement: Slopes found in Reach C are similar to those found in Reach A. However, the gravels are finer and the channel is in-filled to the height of the four Vertical Drop Structures in the reach, VDS 14 – 17. Excavation and gravel replacement would be required to provide the depth of flow and substrate similar to that observed in Reach G.
2. Spawning Riffle Additions: There is sufficient drop below the structures in reach C (Photo 16) to construct at least two riffles similar to those added below drop structure 12 in 2001 (Photo 17). Spawning on the upstream side of the constructed riffles occurs where suitable gravels have been added. The small gravel fill was utilized by spawning sockeye in October 2001. In future years, the fill may be extended further upstream to form a coarse gravel platform.



Photo 16: concentrated fall below drop structure 14 in potential spawning Reach C.



Photo 17: the fall below drop structure 12 is distributed over four riffles constructed in 2001. The drop at the structure is less than 15 cm, allowing easy fish passage upstream and downstream.

5.3 Preliminary Cost Estimates

The following assessments for enhancing spawning and restoring access to Vaseux and Skaha Lakes are based on old surveys (1982) and sketch designs. Unit costs in Table 5 and 6 are based on the 2001 riffle construction project below Vertical Drop Structure 12 in Oliver. Updated surveys and final designs are required to confirm the estimates.

Table 5. Reach A spawning enhancement works

Construction of five riffles with 50 m spawning ramps below the Okanagan Lake outlet Dam	5 @ 25K/riffle	\$ 125,000
	5@ 50K / ramp	\$ 250,000

Table 6. Reach C Spawning enhancement works

excavation and gravel replacement in a 50 m reach above drop structures 14-17	4 x 50m @ 1.5k / m	\$ 300,000.
construction of two riffles with 50 m spawning ramps below drop structures 14-17	4 x 2 @ 25k / riffle	\$ 200,000
	4 x 1 @ 50k / ramp	\$ 200,000

6.0 REFERENCES

Bull, C. 2000. Sockeye Salmon Habitat Assessment In Okanagan River Upstream of McIntyre Dam. Prepared for the Okanagan Nation Fisheries Commission.

Burgner, R.L. 1991 Life History of Sockeye Salmon (*Oncorhynchus nerka*). In Pacific Salmon Life Histories; C. Groot and L. Margolis Ed's. Dept. of Fisheries and Oceans, Biological Services Branch, Pacific Biological Station, Nanaimo, British Columbia, Canada V9R 5K6

Hyatt, Dr. K. D. Personnal Communication (April 5, 2001)

Johnson, N.T. and P.A. Slaney. 1996. Fish Habitat Assessment Procedures. Watershed Restoration Technical Circular No. 8. Ministry of Environment, Lands and Parks and Ministry of Forests.

Schubert, B. 1983. Okanagan Flood Control System maps. Drawing No. A5221. Victoria, BC: Ministry of Environment, Water Management Branch.

Okanagan Nation Fisheries Commission. 2001. Evaluation of an experimental re-introduction of sockeye salmon into Skaha Lake. Submitted to Colville Confederated Tribes.

Summit Environmental Consultants Ltd. 2000. Okanagan River Sockeye Spawning Habitat Assessment. Prepared for Okanagan Nation Fisheries Commission.

Summit Environmental Consultants Ltd. 2000. Okanagan River Redd Scour Study. Prepared for Okanagan Nation Fisheries Commission.

Appendix A

Sockeye Spawning Habitat
Quantity Survey 2001

Reach	Habitat unit			Map #	Photo Number	Comments	Polygon - gravel substrate					Survey Field crew	Survey Date 2001
	Start location	Type	Substrate type				polygon number	polygon shape	poly gon mea sur.	Polygon area (m ²)			
Okanagan Lake													
A	6.287	R	b	1	54,53							KL, KAL, HA, AS	28-May
A	6.240	G	c	1	52							KL, KAL, HA, AS	28-May
A	6.065	R	b	1			1	rec	6	2	12	KL, KAL, HA, AS	28-May
A	5.930	G	c	2	51		2	rec	7	3	21	KL, KAL, HA, AS	28-May
A	5.603	P	bc	3	50							KL, KAL, HA, AS	28-May
A	5.460	G	bc	3								KL, KAL, HA, AS	28-May
A	5.312	G	bg	4			3	rec	11	6	63	KL, KAL, HA, AS	28-May
A	5.191	G	gc	5	49, 48	MELP gravel deposits	4	rec	195	27	5,168	KL, KAL, HA, AS	28-May
A	4.870	P	gc	5								KL, KAL, HA, AS	28-May
A	4.800	G	cg	6								KL, KAL, HA, AS	28-May
			gbc	6		gravel pockets							
A	4.730	G					5	rec	30	14	409	KL, KAL, HA, AS	28-May
A	4.506	R	cg	6	47	riffle crest	6	rec	33	18	581	KL, KAL, HA, AS	28-May
A	4.206	R	cg				7	rec	44	22	957	KL, KAL, HA, AS	28-May
A	4.000	G	cg	7			8	rec	18	12	216	KL, KAL, HA, AS	28-May
B	4.000	P	cb	7, 8, 9								KL, KAL, HA, AS	28-May
B	3.235	P	fg	10 to 17		high amount of weeds						HA, AS	7-Sep
Skaha Lake 0.000													
C	35.922	R	bc	18, 19	46, 45	OK Falls						Klong, Halex, Asnow	28-May
C	35.708	P	bc	19	44							Klong, Halex, Asnow	28-May
C	35.620	R	cg	19		gravel pockets	9	circle	6		24	Klong, Halex, Asnow	28-May
C	35.400	R	cg	19	43		10	circle	8		49	Klong, Halex, Asnow	28-May
C	35.286	R	cg	19		VDS 17	11	circle	6		30	Klong, Halex, Asnow	28-May
C	35.086	G	cb	19, 20	42		12	rec	18	311	5,691	Klong, Halex, Asnow	28-May
C	34.926	G	gf	20		sand						Klong, Halex, Asnow	28-May
C	34.534	G	cf	20			13	rec	12	100	1,230	Klong, Halex, Asnow	28-May
C	34.206	G	f	20-21		sand						Klong, Halex, Asnow	28-May

Reach	Habitat unit			Map #	Photo Number	Comments	Polygon - gravel substrate					Survey Field crew	Survey Date 2001
	Start location	Type	Substrate type				polygon number	polygon shape	poly gon mea sur.	Polygon area (m ²)			
D	33.425	P	fg	21	41, 40, 39	gravel pockets VDS14	14	circle	4		10	Klong, Halex, Asnow	28-May
D	33.425	P	fg	21		gravel pockets	14	circle	3		5	Klong, Halex, Asnow	28-May
D	33.425	P	fg	21		gravel pockets	14	circle	5		20	Klong, Halex, Asnow	28-May
D	33.239	P	f	21 to 25								Klong, Halex, Asnow	28-May
Vaseux Lake 30.692													
E	26.038	P	f	26								Halex, Klong	30-May
E	25.428	P	cf	27								Halex, Klong	30-May
E	25.432	P	fc	28								Halex, Klong	30-May
McIntyre Dam 24.196 Total Spawning Area above the Dam 14,485													
F	24.196	R	b	28								Halex, Klong	30-May
F	24.050	G	b	29								Halex, Klong	30-May
F	24.000	R	b	29								Halex, Klong	30-May
F	23.951	R	bc	29								Halex, Klong	30-May
F	23.652	P	b	29	26, 25							Halex, Klong	30-May
F	23.450	R	cb	29	27		13 a	rec	11	2	22	Halex, Klong	30-May
F	22.600	R	cb	30	24, 23		14 a	rec	9	4	36	Halex, Klong	30-May
F	22.000	R	cg	31	22		15	rec	20	8	160	Halex, Klong	30-May
F	21.779	R	cg	32		Transect 1	16	rec	20	79	1,580	Halex, Klong	30-May
F	21.650	R	gc	32			17	rec	47	8	376	Halex, Klong	30-May
F	21.613	R	cg	32			18	rec	4	15	60	Halex, Klong	30-May
F	21.580	P	b	32								Halex, Klong	30-May
F	21.354	R	g	32								Halex, Klong	30-May
F	21.200	R	gc	32		Transect 2	19	rec	15	72	1,080	Halex, Klong	30-May
F	21.180	R	gf	32		side channel	20	rec	72	2	144	Halex, Klong	30-May
F	20.050	R	gc	33		side channel	21	3 circles	11		285	Halex, Klong	30-May
F	20.050	R	gc	33		main channel	22	rec	62	7	434	Halex, Klong	30-May

Reach	Habitat unit			Map #	Photo Number	Comments	Polygon - gravel substrate					Survey Field crew	Survey Date 2001
	Start location	Type	Substrate type				polygon number	polygon shape	poly gon mea sur.	Polygon area (m ²)			
F	20.900	P	cgf	33								Halex, Klong	30-May
F	20.820	G	gb	33			24	rec	10	17	170	Halex, Klong	30-May
F	20.548	R	cg	33		97 Hwy bridge	25	rec	12	7	84	Halex, Klong	30-May
F	20.244	R	cg	33			26	rec	67	5	335	Halex, Klong	30-May
F	20.000	R	cg	34			27	rec	40	200	8,000	Halex, Klong	30-May
F	19.990	R	cg	34		side channel	28	rec	35	12	420	Halex, Klong	30-May
F	19.830	R	cg	35			29	rec	4	130	520	Halex, Klong	30-May
F	19.814	R	cg	35			30	circle	8		50	Halex, Klong	30-May
F	19.580	R	cg	35			31	rec	20	50	1,000	Halex, Klong	30-May
F	19.580	G	g	35			32	circle	8		50	Halex, Klong	30-May
F	19.409	G	g	35			33	rec	23	4	92	Halex, Klong	30-May
F	19.127	G	g	35			34	rec	55	45	2,475	Halex, Klong	30-May
F	19.127	G	g	35			34	rec	30	30	900	Halex, Klong	30-May
F	18.996	G	g	36	20		35	rec	45	50	2,250	Halex, Klong	30-May
F	18.929	G	g	36			35	rec	70	6	420	Halex, Klong	30-May
F	18.872	R	g	36		side channel	36	rec	6	175	1,050	Halex, Klong	30-May
F	18.650	G	g	36								Halex, Klong	30-May
F	18.451	G	g	36			37	rec	12	40	480	Halex, Klong	30-May
F	18.451	G	g	36			37	rec	30	8	240	Halex, Klong	30-May
F	18.400	G	g	36			38	rec	5	20	100	Halex, Klong	30-May
F	18.400	G	g	36			38	rec	20	6	120	Halex, Klong	30-May
G	18.336	G	g	37, 38			39	rec	36	2076	74,736	Halex, Klong	30-May
H	16.248	R	b	39		VDS13						Halex, Klong	30-May
H	16.152	P	f	39								Halex, Klong	30-May
H	15.994	G	g	39			40	rec	30	55	1,650	Halex, Klong	30-May
H	15.939	P	f	40								Halex, Klong	30-May
H	14.944	G	cg	41	39, 38	Oliver Bridge	40a	rec	21	23	489	Asnow, Klouis	30-May
H	14.903	P	fc	41, 42								Asnow, Klouis	30-May
H	13.075	R	c	43	37		41	rec	93	12	1,117	Asnow, Klouis	30-May
H	13.060	P	c	44								Asnow, Klouis	30-May

Reach	Habitat unit			Map #	Photo Number	Comments	Polygon - gravel substrate					Survey Field crew	Survey Date 2001
	Start location	Type	Substrate type				polygon number	polygon shape	poly gon mea sur.	Polygon area (m ²)			
H	12.759	G	cg	45		VDS10	42	rec	100	24	2,400	Asnow, Klouis	30-May
H	12.700	P	c	45								Asnow, Klouis	30-May
H	12.015	G	c	46		VDS9	43	rec	30	19	555	Asnow, Klouis	30-May
H	11.031	G	cb	47		VDS8	46	rec	20	23	460	Asnow, Klouis	30-May
H	10.838	G	cg	47			47	circle	20		314	Klouis, Asnow, Halex	1-Jun
H	9.419	G	gcb	49		VDS6	49	rec	20	10	200	Klouis, Asnow, Halex	1-Jun
H	7.197	G	c	51, 52		VDS5						Klouis, Asnow, Halex	1-Jun
H	6.418	G	c	53, 54		VDS4						Klouis, Asnow, Halex	1-Jun
H	5.932	G	c	55		VDS3						Klouis, Asnow, Halex	1-Jun
H	4.605	P	c	57-60		VDS2						Klouis, Asnow, Halex	1-Jun
H	1.795	P	c	61-62		VDS1						Klouis, Asnow, Halex	1-Jun
Osoyoos Lake		0.000	Total Spawning Area above the Dam					104,855					

Start Location	measured in km (Schubert 1980)
Unit Length	measured in metres
Habitat Unit Types	G glide, R riffle, P pool, SC side channel
Substrate Types	f=fines, g=gravel, c=cobble, b=boulder

Appendix B

Sockeye Spawning Habitat Quality survey

Polygon Number	Water Depth (cm)	Water Velocity (m/s)	Median substrate	% fines	Suitability of substrate					Polygon UTM coordinates	Survey Crew	Date surveyed
			size (mm)		Substrate uniformity	Milfoil or algae present	Scouring potential	High, med, low, none	Rational			
1	67	0.43	24	0%	gravel, cobble	none	low	med		11U 0310724 UTM 5486330	H. Alex K.Long	20-Jun-01
2	58	0.74	52	10-20%	finer boulders	none	low	med		11U 0310607 UTM 5486119	H. Alex K.Long	20-Jun-01
3	55	0.66	44	15%	gravel cobble	none	low	high		11U 0310539 UTM 5485479	H.Alex K.Long	20-Jun-01
4 Grid 1	60	0.40	27	0%	gravel	none	low	med	KO gravel deposit	11U 0310565 UTM 5485361	H. Alex K.Long	20-Jun-01
4 Grid 2	68	0.43	30	0%	gravel	10%	low	high	KO gravel deposit	11U 0310663 UTM 5485209	H. Alex K.Long	20-Jun-01
5	48	0.50	40	50%	gravel , cobble fines	none	low	none	high % fines	11U 0310890 UTM 5484973	H.Alex K.Long	20-Jun-01
6	51	0.46	65	30%	cobble gravel	10%	low	med		11U 0311007 UTM 5484860	H.Alex K.Long	20-Jun-01
7	54	0.45	42	15%	cobble gravel	none	low	med		11U 0311128 UTM 5484743	H.Alex K.Long	20-Jun-01
8	31	0.29	64	5%	cobble gravel	none	low	med		11U 0311322 UTM 5484553	H.Alex K.Long	20-Jun-01
9	35	0.42	29	10%	cobble gravel	none	low	med		11U 0311494 UTM 5524770	A.Snow H.Alex	21-Jun-01
10	23	0.52	18	10%	gravel cobble	none	low	med		11U 0312545 UTM 5468437	A.Snow H.Alex	21-Jun-01
11	26	0.41	23	25%	gravel	none	low	med		11U 0312564 UTM 5468365	A.Snow H.Alex	21-Jun-01
12	8	0.61	23	30%	cobble gravel	none	low	none		11U 0312623 UTM 54680992	A.Snow H.Alex	21-Jun-01
13	96	0.45	19	30%	sandy gravel	25%	medium	low	milfoil presence	11U 0312669 UTM 54678333	A.Snow H.Alex	21-Jun-01
13a	23	0.77	21	20%	gravel sand	none	low	med		11U 0312809 UTM 5467444	A.Snow H.Alex	21-Jun-01

Polygon Number	Water Depth (cm)	Water Velocity (m/s)	Median substrate	% fines	Suitability of substrate					Polygon UTM coordinates	Survey Crew	Date surveyed
			size (mm)		Substrate uniformity	Milfoil or algae present	Scouring potential	High, med, low, none	Rational			
14	28	0.33	32	30%	gravel cobble	none	low	medium		11 U 0312807 UTM 5466673	A.Snow H.Alex	22-Jun-01
14a	10	not deep enough	32	< 5	gravel	none	med - Vaseux Ck dries and floods	none - high if water is present in Vaseux Cr.		11 U 0315853 UTM 5457644	A.Snow H.Alex K. Long	26-Jun-01
15	18	0.17	35	30%	gravel	none	med.- top of a riffle	med		11 U 0315885 UTM 5457187	K. Long A. Snow H. Alex	26-Jun-01
16	19	0.33	32	10%	gravel	none	med- middle of a riffle	med		11 U 0315808 UTM 5457032	K. Long A. Snow H. Alex	26-Jun-01
17	26-19	0.30	43	15-25	gravel	50% - new this year	med. - braided riffle	med		11 U 0315746 UTM 5456902	K. Long A. Snow H. Alex	26-Jun-01
18	13	0.36	26	25-15	gravel - fines	5%	med. - within a riffle	none	water depth too low	11 U 0315730 UTM 5456939	K. Long A. Snow H. Alex	26-Jun-01
19	22	0.30	27	15%	gravel - little cobble	10%	low- within a glide	low	high - last years spawners used this area	11 U 0135657 UTM 5456783	K. Long A. Snow H. Alex	26-Jun-01
20	18	0.19	35	25%	gravel-cobble	none	Little within a glide	med			K. Long A. Snow H. Alex	26-Jun-01
21	29-34	0.39	50	5%	gravel-cobble	little 2%	low	high		11U 0315521 UTM 5456733	K. Long A. Snow H. Alex	26-Jun-01

Polygon Number	Water Depth (cm)	Water Velocity (m/s)	Median substrate	% fines	Suitability of substrate					Polygon UTM coordinates	Survey Crew	Date surveyed
			size (mm)		Substrate uniformity	Milfoil or algae present	Scouring potential	High, med, low, none	Rational			
22	21	0.45	29	8%	gravel	5%	low	med		11u 0315472 UTM 545666	K. Long A. Snow H. Alex	26-Jun-01
24	37	0.69	51	5%	gravel, cobble, fines	present	low	med		11U 0315185 UTM 5456508	K. Long A.Snow H. Alex	26-Jun-01
25	22	0.47	24	5%	gravel	none	med	med		11U 0314958 UTM 5456078	K.long A. Snow H.Alex	27-Jun-01
26	20	0.30	31	5%	gravel	< 5%	med. Top of riffle	med		11U 0314867 UTM 5455871	K.long A. Snow H.Alex	27-Jun-01
27	28	0.49	32	<5%	gravel - few fines	none	low- middle of glide	med		11U 0314747 UTM 5455620	K.long A. Snow H.Alex	27-Jun-01
28	32	0.50	35	15%	gravel - little cobble	20%	none	high		11U 0314650 UTM 5455686	K.long A.Snow H.Alex	27-Jun-01
29	18	0.38	42	<5%	gravel	none	low	low		11U 0314773 UTM 5455586	K.long A.Snow H.Alex	27-Jun-01
30	27	0.52	25	15%	gravel	none	med. Scour side of river	high		11U 0314738 UTM 5455458	K.long A.Snow H.Alex	27-Jun-01
31	19	0.30	38	10%	gravel	none	none	low		11U 0314706 UTM 5455315	K.long A.Snow H.Alex	27-Jun-01

Polygon Number	Water Depth (cm)	Water Velocity (m/s)	Median substrate	% fines	Suitability of substrate					Polygon UTM coordinates	Survey Crew	Date surveyed
			size (mm)		Substrate uniformity	Milfoil or algae present	Scouring potential	High, med, low, none	Rational			
32	21	0.29	28	<5%	gravel - few cobble	none	low - within a glide	med		11U 0314749 UTM 5455317	K.long A.Snow H.Alex	27-Jun-01
33	17	0.30	34	10%	gravel	none	med. - side riffle	low		11U 0314667 UTM5455121	K.long A.Snow H.Alex	27-Jun-01
34	33	0.61	41	<5%	gravel - cobble	5%	med. - low, middle of a riffle	high		11U 0314588 UTM 5454865	K.long A.Snow H.Alex	27-Jun-01
35	36	0.42	30	15%	gravel/some cobble	none	low	medium		11U 03147575 UTM 54654731	K.long A.Snow H.Alex	27-Jun-01
36	15	0.44	28	10%	gravel	none	med. - bottom of riffle	low		11U 0314552 UTM 5454717	K.long A.Snow H.Alex	27-Jun-01
37	30	0.40	25	20%	gravel/few cobble	none	none - middle of glide	med		11U 0314653 UTM 5454238	K.long A.Snow H.Alex	27-Jun-01
38	37	0.73	26	5%	gravel	less than 5%	low - middle of glide	med		11U 0314666 UTM 5454144	K.long A.Snow H.Alex	27-Jun-01
39 Grid 1	28	0.70	28	<5%	gravel	0	None - channelized	med		11U 0314660 UTM 5453992	K.long A.Snow H.Alex	27-Jun-01
39 Grid 2	39	0.65	27	30%	gravel - fines	none	low - channilized	med		11U 0314374 UTM 5453362	K.long A.Snow H.Alex	27-Jun-01
39 Grid 3	45	0.49	26	5 - 10 %	gravel	none	low - channelized	med		11U 0314058 UTM 5452403	K.long A.Snow H.Alex	27-Jun-01

Polygon Number	Water Depth (cm)	Water Velocity (m/s)	Median substrate	% fines	Suitability of substrate					Polygon UTM coordinates	Survey Crew	Date surveyed
			size (mm)		Substrate uniformity	Milfoil or algae present	Scouring potential	High, med, low, none	Rational			
40	36	0.42	22	25%	gravel/fines	none	low - riffle 40 m upstream	med		11U 0314105 UTM5452093	K.long A.Snow H.Alex	27-Jun-01
40 A	109	0.43	23	30%	gravel/fines a few boulders	none	med - directly above VDS 12	med		11U 0314411 UTM 5450995	K.long A.Snow H.Alex	26-Jun-01
41	120	0.25	21	40%	gravel - sand	none	low - channelized	low	% fines too high	11U 0314895 UTM 5450071	K.long A.Snow H.Alex	26-Jun-01
42	80	0.37	39	20%	cobble gravel fines	not present but near by	low channelized	med		11U 0314781 UTM 5449051	K.Long A.Snow H.Alex	26-Jun-01
43	64	0.42	21	25%	gravel	2%	low	med	small patches	11U 0314229 UTM 5448212	Alex, A.Snow	22-Jun-01
46	40	0.83	32	10%	cobble	none	low	med		11U 0313521 UTM 5447491	K.long A.Snow H. Alex	22-Jun-01
47	59	0.68	20	20%	gravel	none	low	med		11U 03134521 UTM 5447420	K.Long A.Snow H.Alex	22-Jun-01
49	18	0.45	31	20%	gravel	none	low	low	low water wepth	11U 0312442 UTM 5446440	H.Alex A.Snow	22-Jun-01

* Spawning quality is based on the lowest rating of the habitat parameters measured in a given polygon no.

Appendix C

Sockeye spawning habitat
survey summary

Sockeye spawning habitat survey summary **Above McIntyre Dam**

		Spawning Quantity				Spawning Quality			
Reach	Polygon Number	Polygon Areas				Water depth (cm)	Water velocity (m/s)	Median Substrate size (mm)	Percent fines
		High (m ²)	Med (m ²)	Low (m ²)	Not viable (m ²)				
Okanagan lake									
A	1		12			67	0.43	24	0%
A	2		21			58	0.74	52	10-20%
A	3	63				55	0.66	44	15%
A	4 Grid 1		5,168			60	0.40	27	0%
A	4 Grid 2					68	0.43	30	0%
A	5				409	48	0.50	40	50%
A	6		581			51	0.46	65	30%
A	7		957			54	0.45	42	15%
A	8		216			31	0.29	64	5%
Skaha lake									
C	9		24			35	0.42	29	10%
C	10		49			23	0.52	18	10%
C	11		30			26	0.41	23	25%
C	12				5,691	8	0.61	23	30%
C	13			1,230		96	0.45	19	30%
D	14			35		28	0.33	32	30%
Vaseux lake									
MCINTYRE DAM		63	7,046	1,265	6,100				

Sockeye spawning habitat survey summary **Below McIntyre Dam**

Reach	Polygon Number	Spawning Quantity				Spawning Quality			
		Polygon Areas				Water depth (cm)	Water velocity (m/s)	Median substrate size (mm)	Percent fines
		High (m ²)	Med (m ²)	Low (m ²)	Not viable (m ²)				
F	13a		22			23	0.77	21	20%
F	14a				36	10	N/A	32	<5%
F	15		160			18	0.17	35	30%
F	16		1,580			19	0.33	32	10%
F	17		376			26-19	0.30	43	15-25
F	18					13	0.36	26	25-15
F	19			1,080		22	0.30	27	15%
F	20		144			18	0.19	35	25%
F	21	285				29-34	0.39	50	5%
F	22		434			21	0.45	29	8%
F	24		170			37	0.69	51	5%
F	25		84			22	0.47	24	5%
F	26		335			20	0.30	31	5%
F	27		8,000			28	0.49	32	<5%
F	28	420				32	0.50	35	15%
F	29			520		18	0.38	42	<5%
F	30	50				27	0.52	25	15%
F	31			1,000		19	0.30	38	10%
F	32		50			21	0.29	28	<5%
F	33			92		17	0.30	34	10%
F	34	3,375				33	0.61	41	<5%
F	35		2,670			36	0.42	30	15%
F	36			1,050		15	0.44	28	10%
F	37		720			30	0.40	25	20%
F	38		220			37	0.73	26	5%
G	39 Grid 1		74,736			28	0.70	28	<5%
G	39 Grid 2					39	0.65	27	30%
G	39 Grid 3					45	0.49	26	5 - 10 %
H	40		1,650			36	0.42	22	25%
H	40 A		489			109	0.43	23	30%
H	41			1,117		120	0.25	21	40%
H	42		2,400			80	0.37	39	20%
H	43		555			64	0.42	21	25%
H	46		460			40	0.83	32	10%
H	47		314			59	0.68	20	20%
H	49			200		18	0.45	31	20%
Osoyoos Lake									
		4,130	95,569	5,059	36				

Appendix D

Discussion of spawning areas
enhancement and opportunities

Howard Smith, Ecologist

**Discussion of spawning areas
enhancement and opportunities
By: Howard Smith**

Based upon the limited observations of Oct 18, conditions in the channel below the Okanagan Lake Dam (Reach A) were the most promising for development. However, possibly any Okanagan River channel site with sufficient water depth and velocity could be upgraded to a productive spawning area by adding preferred size spawning gravel. The reasons for Reach A being the most promising for development are as follows:

- Gravel stability – minimum tendency to shift downstream in this area where flows are controlled.
- Controlled flow and substrate- because the age and size of Okanagan River sockeye vary little, spawning habitat improvements based on measured preference would meet the needs of the population.
- Low Siltation – it is unlikely that silt/fine sediment would be readily transported and deposited in this reach due to its proximity downstream of Okanagan Lake.
- Access – there are no barriers to fish passage in Reach A.

A range of other factors deserved careful consideration if the reintroduction of sockeye to Skaha Lake is to proceed. These factors include residualism, homing instincts and run size and he noted that many of these factors are likely already being looked at.

Reintroduction of sockeye into Skaha Lake might, through the process of residualism, increase the existing kokanee population at the expense of anticipate seaward migrations. Some level of residualism is likely possible irrespective of the reintroduction process e.g. as eggs, fry or adults either produced in spawning channels or introduced directly into upstream waters.

Early appearing adult sockeye have been reported “bumping their noses” at Skaha Lake dam presumably seeking spawning opportunities farther upstream then eventually returning down river at least as far as Vaseux Lake. This may simply reflect a normal drive on the part of some members of the population to extend their range. However, it could also reflect a strong inherent urge to return to spawning grounds of ancestral populations, perhaps far above in Okanagan Lake or its tributaries.

This behaviour may be largely an “early run” phenomenon but it could mean that the sources of fish and method of reintroduction should be carefully considered as some Skaha selectees may simply swim upstream to the next barrier and repeat the nose bumping there. Some form of physical containment might be necessary if such fish were introduced as adults.

Escapement numbers will continue to fluctuate and some small runs could drastically frustrate attempts to extend the spawning range. There may be merit in establishing well in advance, the proportion of a run that could be used for reintroduction purposes and to negotiate and confirm this use with stakeholders wherever they may be.

More information is needed on the dynamics of the early run of Okanagan River Sockeye. If these fish are remnants of an historic early run originating in the upper lake basins, they might be best part of the stock for use in any reintroduction. Commonly sockeye runs which have two or more components separated by time of migration, send their earliest fish farthest upstream. A number of factors influence this tendency, including travel distance, temperature regimes both en route and at destination, and during spawning and incubation, the timing of food (e.g. plankton blooms) essential for emergent fry in the spring also play a part.

In any event information about the behaviour of the early segment of the Okanagan River sockeye run, though sketchy, seems perfectly consistent with that of a relict population which, seeking cooler water and ancestral spawning grounds upstream, but deprived of both and finding ambient river temperatures rising intolerably, after a time gives up and returns downstream. It is not clear what the fish may do thereafter. To shed more light on the nature of the early run, several specific steps might be taken as follows:

- Measure and record the timing through the river of early fish and any other population units distinguishable by time of passage.
- Measure duration, and describe “nose bumping” behavior at dam(s) to see if it is concentrated in any particular part of the population.
- Tag fish at the highest point of observed migration and record their later movements to see if they persist in their efforts to go farther upstream
- Measure early run size of fish, growth patterns etc. to see if they are morphologically or in any other way distinguishable from the “main run” fish

Appendix E

Spawning reaches and
enhancement feasibility

Bob Newbury PhD PEng
Newbury Hydraulics, Okanagan Centre

Spawning reaches and enhancement feasibility

Task C: Bob Newbury PhD PEng (Newbury Hydraulics, Okanagan Centre)

Spawning and the Okanagan River profile

There are three Okanagan River reaches between lakes from the International border to Okanagan Lake (profile, Figure 4-1). The reach lengths and slopes are:

Reach	Length (km)	Fall (m)	Slope (%)
Osoyoos lake – Vaseux Lake	24	49	0.21
Vaseux Lake – Skaha Lake	4	10	0.25
Skaha Lake – Okanagan Lake	6	2.9	0.048

The existing moderate to highly utilized spawning reaches occur in the steep reaches F and G between Vaseux Lake and Skaha Lake. Reach F is naturally braided and meandering. Reach G is channelized with a suitable gravel bed that is backflooded by drop structure no. 13.

Between Vaseux Lake and Skaha Lake, reach C is similar to reach G but in most years fish passage upstream into the reach is blocked by the McIntyre dam. Reach D has a milder slope and finer bed materials.

Between Skaha Lake and Okanagan Lake, reaches A and B have much less slope than the downstream reaches used for spawning. No drop structures are required to control the gradient. Finer gravels have accumulated or been added to the channelized bed that are used by spawning kokanee. Fish passage to the reach is blocked by the Okanagan Falls (Skaha Lake) dam as well as the McIntyre (Vaseux Lake) dam.

Spawning enhancement in reach A

The low 0.048% gradient in reaches A and B is too shallow to construct significant spawning riffles and platforms throughout the reach. For example, riffles with 0.2 m drop between crests similar to those constructed below drop structure 12 in Oliver (Figure 4-6) would be greater than 400 m apart. The local effects of scour and substrate flow would not occur in the long inter-riffle reach.

However, five riffles and spawning platforms could be added to the upper end of this segment in Reach A by utilizing the fall created by the Penticton (Okanagan Lake) dam. This would increase the local gradient to 0.17% and reduce the riffle spacing to 120 m, approximately 6 times the channel base width. The total riffle reach would extend from 120m below the dam to approximately the Highway 97(Eckhart Road) crossing.

The riffle and ramp design would have to be modified to accommodate tube and raft recreation by using rounded rock and a more carefully sculpted chute. There is some liability involved in changing the now uniform canal into 5 reaches with small drops that would require some steering and negotiation by otherwise freely floating bungheads.

Spawning enhancement in reach C

Successful Spawning Conditions: Sockeye successfully spawned in Reach G above drop structure no. 13 (Figures 4-2 and 4-3). These conditions may be created in Reach C as it has a similar slope and lake exit position.



Figure 4-2: the average velocity was 1.4 m/s and average depth 0.55 m during spawning in reach G on October 18/01. The turbulence in the foreground is caused by spawning sockeye.

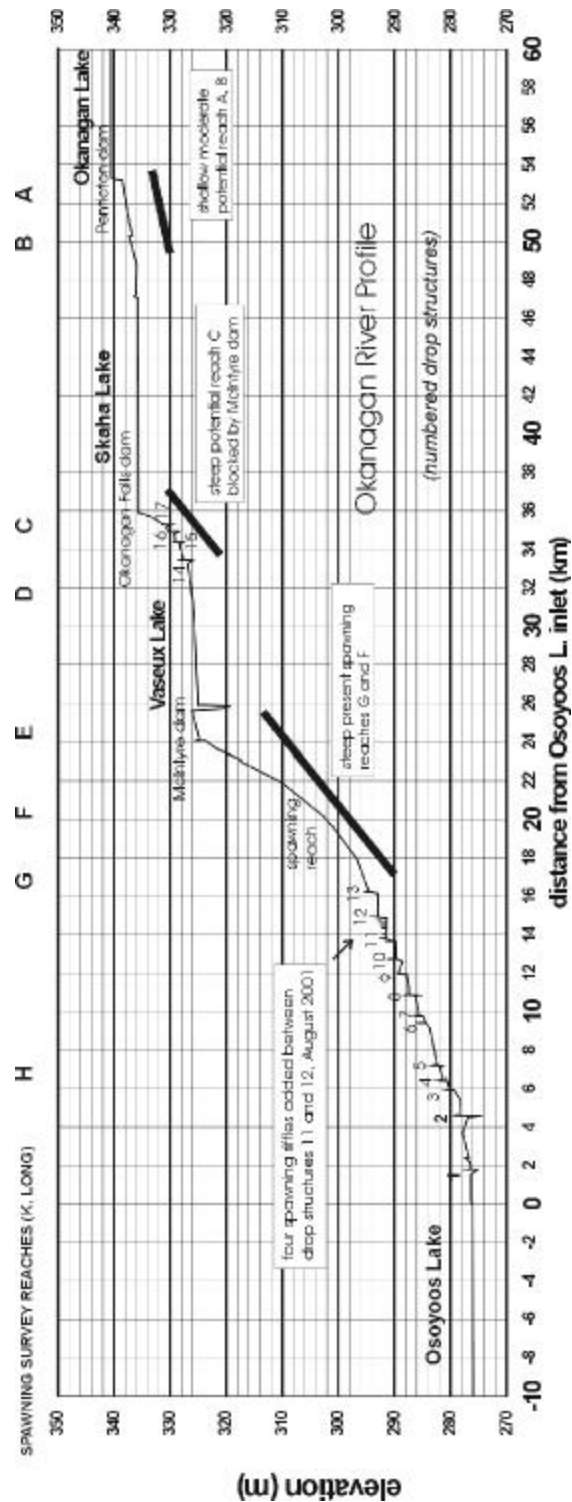


Figure 4-1: the Okanagan River long profile showing spawning reaches and spawning riffles added below drop structure 12 in August 2001.

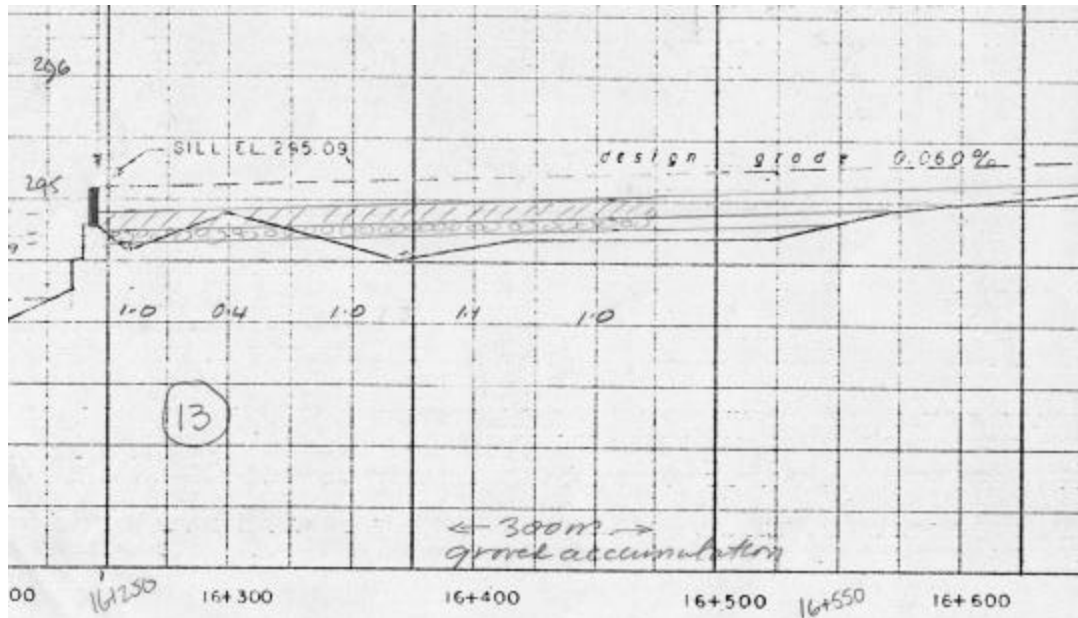


Figure 4-3: profile of reach G above drop structure 13 showing the accumulated spawning gravels on the 1982 survey of the streambed.

Excavation and Gravel Replacement: Similar slopes exist in reach C below Vaseaux Lake. However, the gravels are finer and the channel is infilled to the height of the four drop structures in the reach, numbers 14 – 17. The 1982 profile above drop structures 16 and 17 is shown in Figure 4-4 for example.

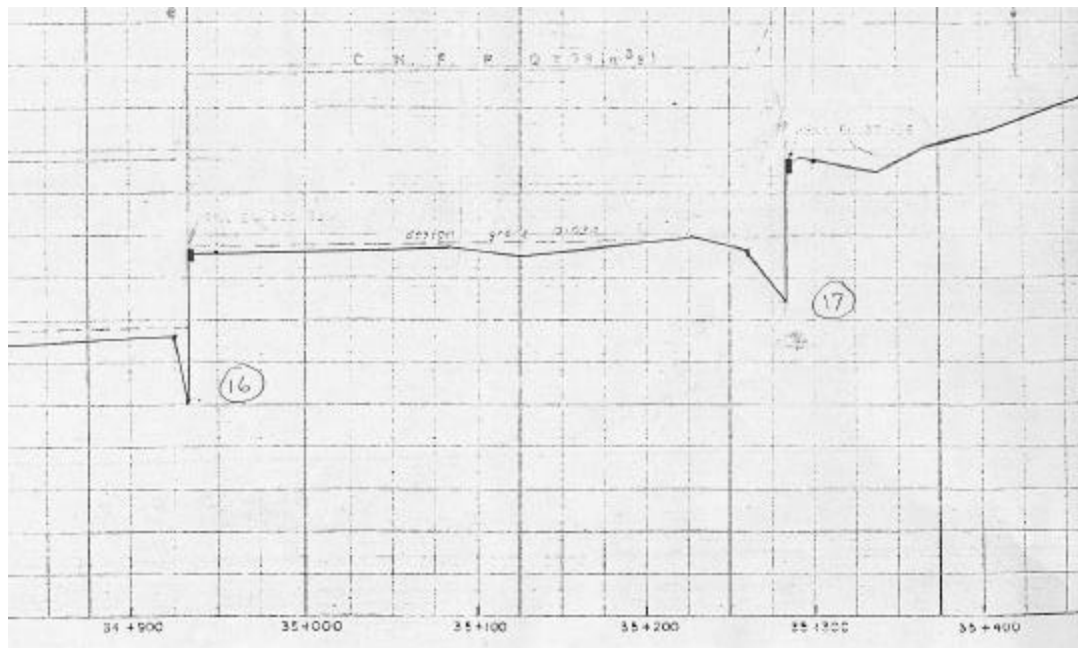


Figure 4-4: infilling above drop structures 16 and 17 in reach C.

Excavation and gravel replacement would be required to provide the depth of flow and substrate similar to that observed in reach G.

Spawning Riffle Additions: There is sufficient drop below the structures in reach C (Figure 4-5) to construct at least two riffles similar to those added below drop structure 12 in 2001 (Figure 4-6).

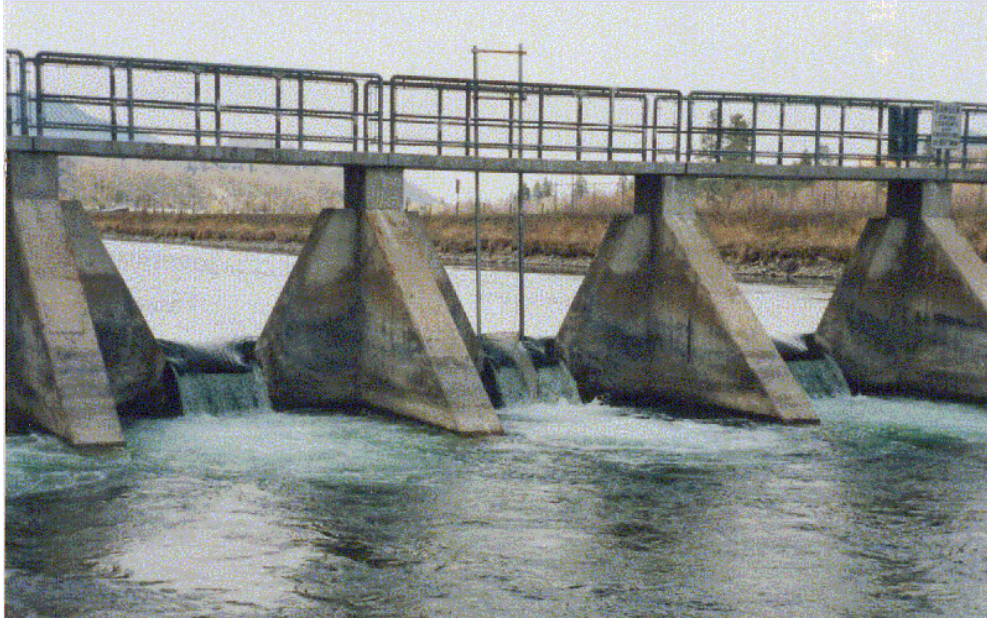


Figure 4-5: concentrated fall below drop structure 14 in potential spawning reach C.



Figure 4-6: the fall below drop structure 12 is distributed over four riffles constructed in 2001. The drop at the structure is less than 15 cm, allowing easy fish passage upstream and downstream.

Spawning on the upstream side of the constructed riffles occurs where suitable gravels have been added. The small gravel fill utilized by spawning sockeye in October 2001 is shown in

Figure 4-7. In future years, the fill may be extended further upstream to form a coarse gravel platform.



Figure 4-7: spawning sockeye in the gravel fill added to the constructed riffles below drop structure 12.

Fish Passage above the McIntyre Dam and Okanagan Falls Dam

In most flow years, fish passage to the steep reach above Vaseaux Lake is blocked by the McIntyre dam. In addition, the Okanagan Falls dam blocks fish passage to the less steep reaches A and B above Skaha Lake. However, stepped pool and riffle side channels may be constructed around the dams that would act as fishways. The higher dam at Okanagan Falls to the less steep reach may not be justified.

The location of passage works around McIntyre dam to allow access to Vaseaux Lake and reach C is shown in Figure 4-8. A pool and riffle channel from the immediate tailrace on the east side of the dam climbs into a pool contained in a horizontal culvert under the irrigation canal. A second stepped channel climbs from the pool to the forebay above the canal water intake. A low bar within the upstream channel can enhance the entry conditions to the fishway from above. Screening of the canal entrance may be required during low flow conditions if the gates are closed and the canal is operating during the out-migration period.

A similar pool and riffle channel may be constructed over the 4 m high Okanagan Falls dam, possibly in the smaller east channel below the dam. In this case rock excavation would increase the cost and complexity of the channel.

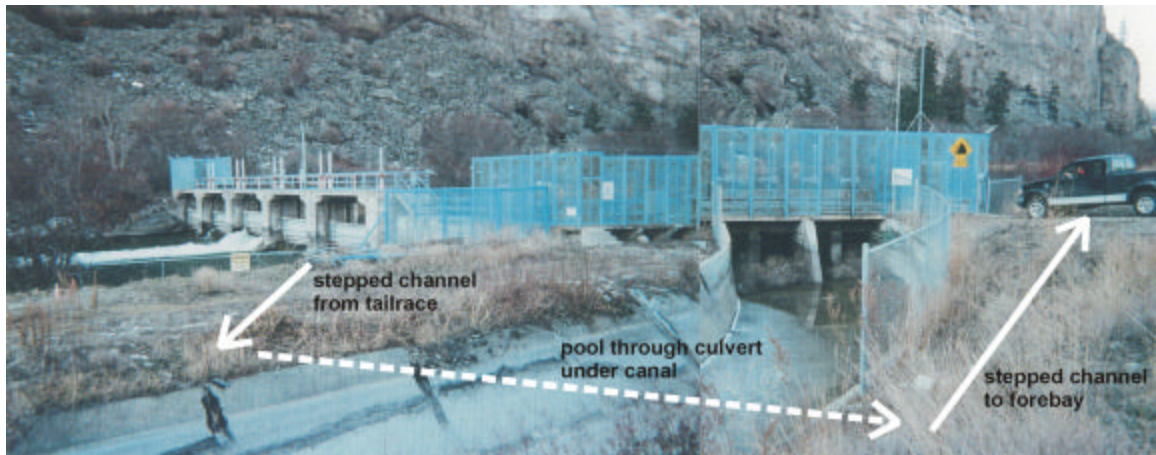


Figure 4-8: Fish passage side channel around McIntyre dam. The channel capacity may be gated and limited to less than $1 \text{ m}^3/\text{s}$ to conserve water during low flow periods.

Similar fishways have been built successfully over the earth-fill portion of other concrete spillway dams. For example, the fishway for the Rapid City dam on the Little Saskatchewan River (Figure 4-9) passes all fish species at a maximum design flow of $0.6 \text{ m}^3/\text{s}$.



Figure 4-9: typical pool and riffle fishway on the earthfill portion of the Rapid City dam, MB. The channel leads from the tailrace to a pool and im[pounded culvert (foreground) that is connected to the forebay through a gated entrance.

Preliminary Cost Estimates

The following assessments for enhancing spawning and restoring access to Vaseaux and Skaha Lakes are based on old surveys (1982) and sketch designs. Unit costs are based on the 2001 riffle construction project below drop structure 12 in Oliver and on the average pool and riffle fishway cost per foot of rise in similar sized works. Updated surveys and final designs are required to confirm the estimates.

1. Reach C spawning enhancement works:

excavation and gravel replacement in a 50 m reach above drop structures 14-17	4 x 50m @ 1.5k / m	\$ 300,000.
construction of two riffles with 50 m spawning ramps below drop structures 14-17	4 x 2 @ 25k / riffle	\$ 200,000
	4 x 1 @ 50k / ramp	\$ 200,000

2. McIntyre Dam (Vaseux Lake) pool and riffle fishway

60 m channel with pool and culvert under canal	15 ft drop @ 6k / ft	\$ 90,000
gated control structure and upstream bars	standard Ducks Unlimited sliding gate design for culverts	\$ 15,000

3. Reach A spawning enhancement works

construction of five riffles with 50 m spawning ramps below the Penticton (Okanagan Lake) dam	5 @ 25k / riffle	\$ 125,000
	5 @ 50k / ramp	\$ 250,000

4. Okanagan Falls Dam (Skaha Lake) pool and riffle fishway

100 m channel	13 ft drop @ 6k / ft	\$ 78,000
rock excavation	50% surcharge	\$ 39,000
gated control structure and upstream bars	standard Ducks Unlimited sliding gate design for culverts	\$ 15,000

December 13, 2001

Edited January 5, 2002

Appendix F
Resumes

Bob Newbury PhD PEng
Howard Smith, Ecologist

CV: Robert Newbury PhD PEng

B Sc Civil Engineering (Manitoba) 1962
M Sc Water Resources Engineering (Manitoba) 1964
Ph D Environmental Engineering Science (Johns Hopkins) 1968

P Eng Association of Professional Engineers and Geoscientists of British Columbia
P Eng Association of Professional Engineers of New Brunswick (license)



Bob was born and raised in Fort Rouge, Winnipeg. All his employment has been river related, first as a surveyor for the Manitoba Water Resources Branch during undergraduate years and then as a professional engineer working on the Winnipeg floodway model and Nelson River hydroelectric planning. Following the completion of his doctoral studies in 1968, Bob joined the University of Manitoba Engineering and Earth Sciences Faculties and was a sub-consultant to Mollard and Associates (Polargas Pipeline routing) and the Fisheries Research Board of Canada (Experimental Lakes design). Consulting in Manitoba and a major study of northern river diversions ended abruptly in 1975 when a court injunction against the Churchill River diversion undertaken with the people of Southern Indian Lake failed. Bob joined the Freshwater Institute of Fisheries and Oceans Canada as a research scientist to monitor the subsequent Churchill River diversion. The study was completed in 1984 and published as a special issue of the Canadian Journal of Fisheries and Aquatic Sciences (Vol. 41:4). After the completion of the Churchill River-South Indian Lake project, Bob left Manitoba to establish Newbury Hydraulics in British Columbia and to teach part-time in the School of Resource and Environmental Management at Simon Fraser University until 2001. Presently river restoration projects for Atlantic and Pacific salmon, workshops and short courses are undertaken in several countries through Newbury Hydraulics and through several universities and colleges (see www.newbury-hydraulics.com for a list of current course schedules).

Recent Projects

Okanagan River fish passage design (Okanagan First Nations), Theodosia River dam removal review (BC Min. of Environment), Cheakamus River dam review (BC Hydro), Twin Creeks diversion and habitat restoration (Sechelt Creek Contracting), Campbell River gravel recruitment (DFO - BC), SW Miramichi River holding pool restoration (Sutter Salmon Club), Rafting Ground Brook Restigouche River stabilization (Runnymede Lodge), Chamcook Stream St. Andrews NB fish passage and habitat restoration (Atlantic Salmon Federation), Sakinaw Lake BC fish ladder (Sechelt Indian Band, DFO), Oulette Creek BC pool and riffle restoration (Terminal Forest Products), Waukegan River, IL pool and riffle restoration (USEPA, IL State Water Survey), Cranberry Creek dam removal study, BC. (BC Hydro), Davis Brook, BC diversion and habitat restoration (Sandy Hook Community Association/DFO), Don River, ON: "Bring Back the Don" restoration study (Toronto and Region Conservation Authority).

Recent Courses and Workshops

University of Cantabria, Simon Fraser University, University of Calgary, University of Regina, University New Brunswick, Okanagan University College, Atlantic Salmon Federation, Arkansas Fish and Game, US EPA/Illinois State Water Survey, Forestry Engineering Program (IFEBC) University of British Columbia, Tasmania Department of Environment, Queensland Department of Primary Industries, Victoria State Water Resources, New Brunswick Fish and Wildlife, Canada Institute of Ocean Sciences, Water Survey Battle Creek Training Workshop, Ontario Mines and Natural Resources, CEMAGRAF University of Lyon.

Related Publications

Newbury, R. 2001. Designing Stream Restoration Works: Notes and Exercises. Waterloo Education. 150p.

Newbury, R., N. Glozier, D. Sauchyn and M. Vetter. 2000. The Battle Creek Stream Exploration Workbook. Water Survey of Canada Technical Report. 220p.

Walker, D.R., R. Miller and R. Newbury. 2001. Energy losses across natural and constructed riffles. Proceedings, CWRA Whistler Conference.

Dodson, J.L. et al. 1998. Elements in the development of a conservation plan for Atlantic salmon. CJFAS:55 supp. 1:312-323.

Newbury, R.W., M.N. Gaboury and D.J. Bates 1997. Creating habitats in channelized or uniform streams using riffles and pools. in "Stream Restoration Manual" British Columbia Forest Renewal Program, Victoria BC. 46p.

Newbury, R.W. 1996. Hydraulics: dynamics of flow. in "Methods in stream ecology" ed. Hauer, F.H. and G.A. Lamberti. Academic Press, Orlando. 20p.

Newbury, R.W. 1995. Rivers and the art of stream restoration. in "Natural and anthropogenic influences in fluvial geomorphology" ed. Costa, J.E. et al. AGU Geophysical Monograph 89, Wolman Volume, 137-149. Wash.

Gaboury, M.N., R.W. Newbury and C.M. Erickson. 1995. Pool and riffle fishways for small dams. Technical Report, Manitoba Fisheries, Winnipeg. 30p.

Newbury, R.W. and M.N. Gaboury. 1993, 1994 2nd ed. Stream analysis and fish habitat design: field manual. Newbury Hydraulics Ltd. 256p.

Newbury, R.W. 1993 Streamlab teaching guide. Newbury Hydraulics Ltd. 19p.

Newbury, R.W. and G.K. McCullough. 1983. Shoreline erosion and restabilization in a permafrost-affected impoundment. p. 918-923. Proceedings, IV Int. Conf. On Permafrost.

Newbury, R.W., G.K. McCullough, and R.E. Hecky. 1984. The Southern Indian lake impoundment and Churchill River diversion. Can. J. Fish. Aquat. Sci. 41; 548-557.

Newbury, R.W. and G.K. McCullough. 1984. Shoreline erosion and restabilization in the Southern Indian Lake Reservoir. Can. J. Fish. Aquat. Sci. 41: 558-566.

Bodaly, R.A., D.M. Rosenberg, M.N. Gaboury, R.E. Hecky, R.W. Newbury, and K. Patalas. 1984. Ecological effects of hydroelectric development in northern Manitoba, Canada: the Churchill-Nelson River diversion, p. 273-310. In P.J. Sheehan et al. [ed.]. Effects of pollutants at the ecosystem level, SCOPE 22, John Wiley & Sons, Chichester, New York.

Hecky, R.E., R.W. Newbury, R.A. Bodaly, K. Patalas, and D.M. Rosenberg. 1984. Environmental Impact Prediction and Assessment: the Southern Indian Lake Experience. Can. J. Fish. Aquat. Sci. 41; 720-732.

Newbury, R.W., K.G. Beaty, and G.K. McCullough. 1978. Initial shoreline erosion in a permafrost affected reservoir, Southern Indian Lake, Canada. p. 833-839. Proceedings, III Int. Conf. On Permafrost, Edmonton, Alberta.

Newbury, R.W. , G.K. McCullough, S. McLeod, and R. Oleson. 1973. Characteristics of Nelson-Churchill River shorelines; physical impact study. Technical Report. Department of Civil Engineering, University of Manitoba, Winnipeg, Man. 156p.

Theses and Awards:

BSc: A Sedimentation Model for the South Saskatchewan River Reservoir
(Doupe Memorial Gold Medal in Civil Engineering)

MSc: A Flume/Wind Tunnel Study of Wind Setup on Irregular Water Bodies
(University of Manitoba Teaching Fellowship)

PhD: The Nelson River: A Study of Sub-Arctic River Processes
(Ford Foundation Fellowship for University Educators, Whiting Fellowship JHU)

Curriculum vitae
Howard D. Smith

(as provided to the Okanagan Nation Fisheries Commission)

PERSONAL INFORMATION

Residence:	505 James lake Road P.O. Box 43 Rock Creek, B.C.
Citizenship:	Canadian
Family:	Married with 3 children and 5 grandchildren

WORK RELATED INFORMATION

Education:	Canada, South Africa, and U.S.A.
Post-Secondary Institutions:	University of British Columbia – Agr (1 year) University of Washington, Seattle – BSc., MSc. Fisheries Major
Employment:	
1943-1945	Royal Canadian Air Force
1950-1960	Fisheries Research Institute, University of Washington Research Biologist
1960-1986	Canada Department of Fisheries (currently DFO) Research Scientist, Administration
Secondments:	
1959-1960	Laboratory of Radiation Biology University of Washington
1975-1976	Canadian International Development Agency Kasetsart University, Bangkok, Thailand Program Administration
Publications:	30 sole and joint authorships including primary technical and manuscript reports

FINAL

Evaluation of an Experimental Re-introduction of Sockeye Salmon into Skaha Lake

OBJECTIVE 3 Task D

Assessment of Juvenile *Oncorhynchus nerka* (Sockeye and Kokanee) Rearing Capacity of Skaha Lake, Vaseux Lake, and Osoyoos Lake 2001

Submitted to: Chris Fisher
Colville Confederated Tribes

Prepared by:
Howie Wright, Biologist

Submitted by:
Okanagan Nation
Fisheries Commission

April 2002

EXECUTIVE SUMMARY

Data collected during the 2001 sampling season, and the relationship between total dissolved phosphorus and total biomass of fish, provide for estimates of the rearing capacity for Sockeye Salmon (*Oncorhynchus nerka*) smolts both 86mm and 100mm in length in three Okanagan Valley lakes: for Skaha Lake estimates of smolts per hectare are 2,781 and 1,977; for Vaseux Lake they are 3,047 and 2,167; and for Osoyoos Lake they are 2,981 and 2,119. Skaha Lake and Osoyoos Lake are similar in their rearing potential based on this relationship. However, there are many other factors, both biotic and abiotic, that affect the estimates for these lakes.

Secchi disc depths related well with the levels of productivity measured in Skaha, Vaseux and Osoyoos Lakes with decreasing depths with increases in phosphorus concentration. In terms of temperature and oxygen limitations, wherein one day/month samples were used as representative of conditions for the entire month, Skaha Lake had the greatest amount of preferable habitat for juveniles, while Vaseux Lake had no suitable habitat, and Osoyoos Lake had suitable habitat only in the north basin. When comparing Skaha to current juvenile Okanagan sockeye rearing conditions (north basin of Osoyoos Lake), temperature and oxygen conditions are likely not an issue in Skaha Lake.

The total nitrogen to total phosphorus (TN:TP) ratio suggests that Skaha production is phosphorus limited, that Vaseux Lake is nitrogen limited, and that the north basin of Osoyoos Lake is phosphorus limited. However, the Osoyoos Lake central basin at Site 3 is initially phosphorus limited, but that changes to nitrogen limited in the summer. At the south basin at Site 4 it could be either phosphorus, or nitrogen, but probably it is phosphorus limited. A positive relationship between increases in total phosphorus and chlorophyll *a* are seen in Skaha and Osoyoos Lakes, but not in Vaseux Lake which may be due to nitrogen limitation and conditions favourable for cyanobacteria. Because silica levels did not vary greatly in all lakes sampled they are thought not to be limiting.

Cyclopoids and Diaptomids were the dominant macrozooplankton in Skaha Lake, Vaseux Lake, and Osoyoos Lake. Daphnia were at lower densities and biomass in Skaha Lake and the north basin of Osoyoos Lake compared to Vaseux Lake and the central and south basins of Osoyoos Lake and is likely due to the grazing pressures of *Mysis relicta* and juvenile *O. nerka*. Mean lengths of zooplankton and densities of the 0.9-1.5mm zooplankton were generally greater in Skaha Lake than the north basin of Osoyoos Lake. This is attributed to the presence of more *O. nerka* than *Mysis relicta* in the north basin of Osoyoos Lake compared to the more *Mysis relicta* than *O. nerka* in Skaha Lake. Overall, there were no significant differences between Skaha Lake and the north basin of Osoyoos Lake in terms of zooplankton, other than *Mysis relicta*.

Mysis relicta was not found in great amounts in Vaseux Lake and the central and south basins of Osoyoos Lake. This is likely due to the short residence time of Vaseux Lake and the temperature and oxygen limitations in the central and south basins of Osoyoos Lake. *Mysis relicta* were found in Skaha Lake and the north basin of Osoyoos Lake. Skaha Lake had greater density, biomass and mean lengths.

Kokanee populations in Skaha Lake are thought to be depressed compared to historical numbers. The effects of *Mysis relicta* on the potential rearing capacity and the current rearing capacity of Okanagan sockeye is still relatively unknown and more evaluation on this issue is required.

Skaha Lake is similar, and in some cases better, for rearing of Okanagan sockeye when compared to current rearing conditions. However, *Mysis relicta* are in greater abundance in Skaha Lake compared to the north basin of Osoyoos Lake.

Recommendations arising from these findings are:

1. Further sampling and comparison of Skaha Lake and the north basin of Osoyoos Lake,
2. Discontinuation of sampling on Vaseux Lake and the central and south basin of Osoyoos Lake,
3. Compilation of historical and current kokanee information of Skaha Lake,
4. Compare predicted versus observed kokanee abundances for Skaha Lake using the total phosphorus to fish biomass relationship to verify relationship.
5. Continue revised monthly water quality sampling (physical and chemical) of Skaha Lake (two sites) and the north basin of Osoyoos Lake (two sites).
6. Biweekly *Mysis relicta* and zooplankton sampling. Sampling methodology used in 2001 is recommended with the exception that no replicates taken.
7. Collection of kokanee information from Skaha Lake including juvenile monitoring, diel migration monitoring (in conjunction with *Mysis relicta*), and growth rates of maturing kokanee.
8. Collect juvenile sockeye diel migration information (in conjunction with *Mysis relicta*), and of the time juvenile *O. nerka* are in the Osoyoos Lake littoral zone.

ACKNOWLEDGEMENTS

The Okanagan Nation Fisheries Commission would like to acknowledge the following people and organizations for their valuable contribution Task 3d: Assessment of Juvenile *Oncorhynchus nerka* (Sockeye and Kokanee) Rearing Capacity of Skaha Lake, Vaseux Lake, and Osoyoos Lake 2001. Compilation of this report would not have been possible without the group effort of the staff of ONFC and all other parties involved.

Thanks to Kim Hyatt and Paul Rankin of Fisheries and Oceans Canada at the Pacific Biological Station and Steve Matthews of the Ministry of Water, Land and Air Protection (MoWLAP) Penticton Fisheries Branch for their support and review of methodology, data analysis, and reporting. Vic Jensen of the Ministry of Water, Land and Air Protection (MoWLAP) Penticton Pollution Prevention Branch for his support with water chemistry analysis, lab access, data analysis, and reporting.

Thanks to Mark Johannes of the Northwest Ecosystem Institute (NEI) for his input on data analysis and reporting.

Carol Cooper of AMC Services conducted the Zooplankton and *Mysis relicta* analysis. Environment Canada North Vancouver Lab conducted the water chemistry analysis.

Howard Smith provided a thorough and insightful senior review and editing of the report.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
 1.0 INTRODUCTION	 1
 2.0 METHODOLOGY	 1
2.1 Rearing Capacity	3
2.2 Physical Limnology and Water Chemistry.....	3
2.2.1 Physical Limnology	3
2.2.2 Water Chemistry.....	4
2.3 Macrozooplankton.....	4
2.4 Mysis Relicta.....	5
 3.0 RESULTS.....	 5
3.1 Rearing Capacity	5
3.2 Physical Limnology and Water Chemistry.....	6
3.2.1 Physical Limnology	6
3.2.2 Water Chemistry.....	9
3.3 Macrozooplankton.....	12
3.4 Mysis Relicta.....	12
 4.0 DISCUSSION/CONCLUSIONS.....	 13
 5.0 RECOMMENDATIONS.....	 16
 6.0 BIBLIOGRAPHY	 18
 APPENDIX A - Figures 1 through 23	 20

LIST OF FIGURES AND TABLES

Figure 1. Sampling sites.....	2
Table 1. Summary of Sampling Stations	1
Table 2. Summary of Predicted Juvenile <i>O. nerka</i> Rearing Capacities for Skaha Lake, Vaseux Lake, and Osoyoos Lake, 2001.....	5
Table 3. Summary of seasonal average density, biomass, and mean length of <i>Mysis relicta</i> from Skaha Lake and the north basin of Osoyoos Lake, 2001.....	13

1.0 INTRODUCTION

One of the last two significant sockeye salmon populations of the Columbia River system spawns in the Okanagan River in British Columbia. However, in recent years, their population has been declining to levels of concern (Hyatt & Rankin 1999). A long-term restoration goal is to reintroduce sockeye into Okanagan Lake to increase spawning and rearing habitat. Prior to this, it has been proposed to reintroduce sockeye back into Skaha Lake. With funding from the Columbia Basin Fish and Wildlife Program of the Bonneville Power Administration, the Okanagan Nation Fisheries Commission (ONFC) and the Colville Confederated Tribes (CCT) are currently evaluating the proposal reintroduce sockeye into Skaha Lake. One concern being investigated is the rearing capacity of Skaha Lake, which may be a limiting factor in the success of reintroducing sockeye into Skaha Lake.

The objective of this report is to calculate the rearing capacity of three lakes-Skaha, Vaseux, and Osoyoos Lakes in relation to the factors influencing their rearing capacities. Okanagan Lake was initially included as part of the project. However, as it has a similar sampling plan through the Okanagan Lake Action Plan (OLAP), a different program managed by the Ministry of Water, Land and Air Protection (MoWLAP), it was excluded from this project (Andrusak et al. 2001). However, with the inclusion of Osoyoos Lake we will be able to describe and compare the current juvenile rearing conditions for Okanagan sockeye in Osoyoos Lake to the potential rearing conditions in Skaha Lake.

2.0 METHODOLOGY

Selection of sample stations was based on lake-morphometry and used in the past by other Canadian government agencies. Three sites were chosen for Skaha Lake, one for Vaseux Lake, and four sites for Osoyoos Lake (Fig. 1). Table 1 lists sampling stations. All sites were sampled for physical limnology, water chemistry, phytoplankton, zooplankton, and *Mysis relicta*, except for Osoyoos Lake Site 1. Osoyoos Lake Site 1 was not sampled by this program but by the Ministry of Water, Land, and Air Protection (MoWLAP) Pollution Prevention Program, and only in February and October 2001. Physical limnology and water chemistry methodology was based on (OLAP) methodology for comparability and consistency, (Andrusak et al. 2000). Zooplankton and *Mysis relicta* sampling was based on methodology as described in Rankin et al. (2000).

Table 1. Summary of Sampling Stations

Lake	Site ID	Site No.	Site Name	Depth (m)
Skaha	1	0500453	Skaha @ River mouth	45.45
Skaha	2	0500615	Skaha @ Gillies	53.03
Skaha	3	0500846	Skaha @ South Basin	37.87
Vaseux	1	E220331	Vaseux Deep Center	24.24
Osoyoos	1	0500249	Osoyoos @ North Basin	37.87
Osoyoos	2	0500728	Osoyoos @ Monashee Co-op	60.6 m
Osoyoos	3	E220540	Osoyoos @ Central Basin	30.3 m
Osoyoos	4	0500248	Osoyoos @ South Basin	22.72 m

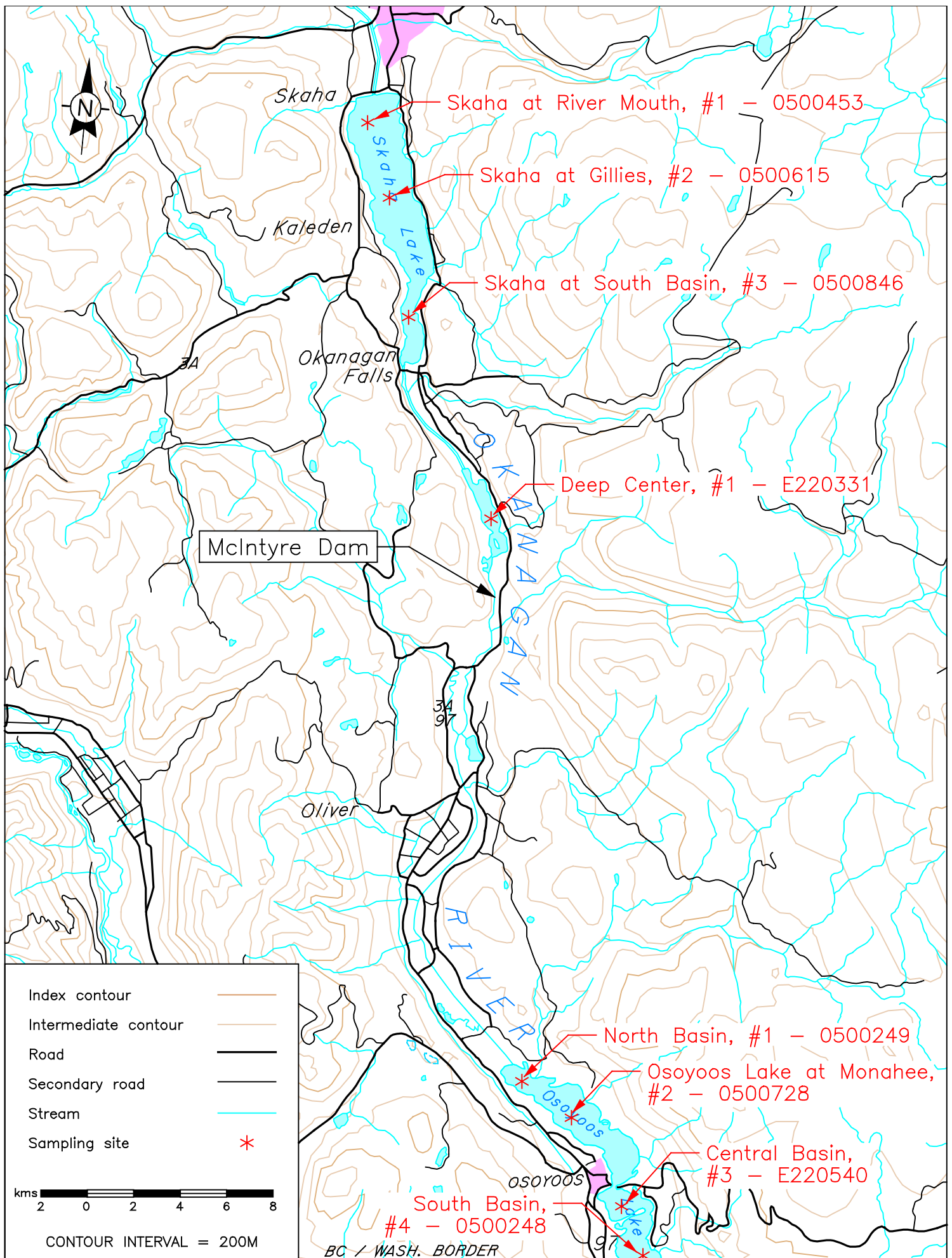


Figure 1. Rearing sampling sites.

2.1 Rearing Capacity

For comparability and discussion of 2001 data, the rearing capacity was calculated for Skaha, Vaseux and Osoyoos Lakes using the relationship between total phosphorus and total fish biomass (Hanson & Leggett 1982, Stockner 1987, Downing et al. 1990). This relationship has also been used by Hyatt and Rankin (1999) to calculate the rearing capacity of Osoyoos Lake and is based on many years of data from north temperate lakes. Total phosphorus concentrations and juvenile sockeye or kokanee biomass of north temperate lakes were used to develop this relationship and the regression equation developed is used to predict total fish biomass for lakes where total phosphorus concentrations are measured. It has worked well in other British Columbia rearing lakes, including Osoyoos Lake (Hyatt & Rankin 1999). In addition, this method accounts for seasonal variability of environmental factors (Hyatt & Rankin 1999).

2.2 Physical Limnology and Water Chemistry

Physical limnology and water chemistry measurements were made at all stations, except for Osoyoos Lake Site 1 where water chemistry parameters were sampled by a different program (MoWLAP Pollution Prevention Program).

2.2.1 Physical Limnology

At each sample site, temperature ($^{\circ}\text{C}$) and dissolved oxygen profiles (mg/L) were taken from the top to the bottom in 2m intervals using a calibrated oxyguard[®] dissolved oxygen meter measured to the nearest 0.1 mg/L. The maximum depth that can be measured with this instrument is 28m. Secchi disk depth was also measured. A zone of tolerance was delineated for each lake, based upon water temperature ($>17^{\circ}\text{C}$), and dissolved oxygen ($<4\text{mg/L}$), tolerances of *O. nerka* to approximate the amount of vertical habitat available in the hypolimnion (Rankin 2001, personal communication).

2.2.2 Water Chemistry

Water chemistry was collected during the daylight with three samples from each lake site taken. The samples were taken from 0-10m depth (integrated) using discrete samples taken at 0m, 5m, 10m depths and one third of sample bottle filled with each discrete depth, and discrete samples at 20m and 45m. Plastic 1L bottles were rinsed three times prior to collecting.

Two additional integrated samples were put in clear 250mL glass jars and preserved with Lugol's iodine solution.

An additional integrated (0-10m) sample was taken and put in brown plastic 1 L bottles for chlorophyll *a* analysis. The samples were filtered and preserved with 2 drops of Magnesium Carbonate (MgCO_3), then frozen and shipped on ice in sealed plastic bags with a small amount of silica gel to the Environment Canada Laboratory in North Vancouver along with water samples. The Lugol's preserved phytoplankton replicate samples were stored at the Okanagan Nation Fisheries Commission storage if it is later determined in the study that phytoplankton analysis is required.

2.3 Macrozooplankton

Macrozooplankton sampling was conducted once per month, within 5 days of the new moon to increase efficiency of capture of *Mysis relicta* due to their light sensitivity. Sampling was conducted at night using a plankton net (terminal mesh size of 105 microns). Two replicate vertical hauls were completed at each sample site. Samples were put in 250mL glass jars and preserved in 4% formalin. One replicate was shipped for analysis to the Pacific Biological Station (PBS) in Nanaimo, BC and the other replicate stored at the ONFC office.

Sprules et al. (1981) provides a summary of the methodology used to analyze zooplankton and *Mysis relicta* samples. The samples were initially stained with methylene blue for contrast purposes (visibility) when measuring. The formalin solution was then decanted from the sample jar and then poured into a Folsom splitter and split as required. Once the split number was determined it was poured into a round-bottomed graduated flask and the water level raised to 300 ml. An automatic pipette taking subsamples of 3 mL and its multiples were taken and placed in a plankton wheel for identifying, enumerating, and measuring. Both a regular count and rare scan was conducted.

The samples were processed using an IBM computer based caliper measuring system and dissecting scope. A program called Zebra2 was used to generate a bench (summary) sheet and save individual measurements and counts to a file.

2.4 Mysis Relicta

Mysis relicta sampling was also conducted once per month within 5 days of the new moon. Sampling was conducted at night using a *Mysis relicta* net (terminal mesh size of 300 microns). Two replicate vertical hauls were completed at each sample site. Samples were preserved in 4% formalin in 500mL glass jars. One replicate was shipped for analysis to the Pacific Biological Station in Nanaimo, BC and the other replicate was stored at the ONFC office for later use if needed. Samples were processed similarly as described in the macrozooplankton abundance methodology.

3.0 RESULTS

3.1 Rearing Capacity

Lake rearing capacities as determined from the described sampling are given in Table 2. Factors influencing these data are discussed later. Figure 2 shows the relationship between total phosphorus and fish biomass used to calculate total fish biomass per hectare for each lake. Figure 3 shows the length-weight regression used to calculate the number of smolts per hectare for each lake. Sockeye smolt lengths of 86mm and 100mm were used for the calculations as these were used by Hyatt and Rankin (1999) so as to be consistent and comparable with their rearing estimate of Osoyoos Lake. With this relationship, juvenile sockeye smolt lengths of 86mm and 100mm would have mean weights of 6.79g and 9.55g respectively. The average total phosphorus was measured from May to September 2001. All measurements per site were summed and divided by the number of measurements. For example, Skaha Lake had three sites with a total of 59 samples (approximately 20 for each site). The sum of all the total phosphorus readings was 712.13µg/L. Therefore, the seasonal average for Skaha Lake was about 12µg/L. Using Figure 1, a fish biomass of 18.88kg/ha was calculated. This 18.88 kg/ha of total fish biomass was divided by the mean weight of 86mm and 100mm sockeye smolts to calculate the number of smolts per hectare. The number of smolts per hectare for 86mm and 100mm are 2,781 and 1,977 respectively.

Table 2. Summary of Predicted Juvenile *O. nerka* Rearing Capacities for Skaha Lake, Vaseux Lake, and Osoyoos Lake, 2001

Lake	Lake Area (ha)	No. of Sites	TP (mg/L)	Fish Biomass (kg/ha)	No. of smolts (86mm)/ha (6.79g)	No. of smolts (100mm)/ha (9.55g)
Skaha	2,010	3	12.0	18.88	2,781	1,977
Vaseux	56.90	1	15.0	20.69	3,047	2,167
Osoyoos**	1505	4	14.2	20.24	2,981	2,119

****Canadian Portion only for lake area**

For Vaseux Lake and Osoyoos Lake the lower depth measurements were omitted because of the anoxic conditions that caused an irregular increase in total phosphorus in the hypolimnion (Johannes 2002, personal communication). For example, the epilimnion reading (0-10m) for Vaseux Lake in September was 0.006mg/L yet the deep sample was 0.227mg/L (Figure 12d). This would have resulted in a larger fish biomass estimate for the lakes that would not be representative of environmental conditions.

The Osoyoos Lake average total phosphorus used for 2001 is consistent with what Hyatt and Rankin (1999) used for their calculation of a total phosphorus concentration of 22 µg/L. Therefore, the rearing potential of Skaha Lake and Osoyoos Lake are similar. However, there are other abiotic and biotic factors that affect this relationship.

3.2 Physical Limnology and Water Chemistry

3.2.1 Physical Limnology

Skaha Lake

Skaha Lake secchi depth measurements averaged 5.2m at the three sites (Figure 4a). A maximum depth of 6.3m was recorded in August at site 3 and the minimum depth was 3.7m at site 1 in October.

Maximum surface temperatures at the three sites in Skaha Lake occurred during August and were 21.3°C, 21.5°C, and 22.2°C at sites 1, 2, and 3 respectively.

Skaha Lake began to stratify during May when the epilimnion boundary was about 8m (Figures 5a,b, and c). During the months of June, July and August site 1 of Skaha Lake progressively developed conditions unsuitable for juvenile sockeye as temperatures of about 19 °C extended to a depth of 40m (Figures 5d, g, and j). Sites 2 and 3 of Skaha Lake had similar conditions with an epilimnion of about 8m and a thermocline at about 12m for the months of June and July (Figures 5e, f, h, and i). In August, the epilimnion at sites 2 and 3 settled to a depth of about 20m and the thermocline was at about 24m (Figures 5k and l). Stratification was still occurring in September when the Skaha Lake Site 1 epilimnion was at about 12m and the thermocline was at about 18m (Figure 5m). The epilimnion of site 2 for September was greater than 28m (Figure 5n). At site 3, the epilimnion settled to a depth of 16m with the thermocline at about 20m (Figure 5o). By October, all sites were isothermal at about 10 °C (Figures 5p, q, and r). In November, all sites began to stratify again with surface temperatures at about 15 °C decreasing to bottom temperatures of 7 °C (Figure 5s, t, and u).

Dissolved Oxygen levels in Skaha Lake were relatively constant, ranging between 9-12 mg/L at sites 1 and 2 and 7-12 mg/L at site 3. Summer profiles were slightly clinograde suggesting waters of moderate productivity (Horne & Goldman 1994). Dissolved oxygen measurements were recorded to a depth of 28m so anoxic conditions could have been occurring below this depth. However, August site 1 measurements revealed no anoxic conditions to a depth of 48m (Figure 5j). In addition, Ministry of Water, Land, and Air Protection (MoWLAP) Water Pollution Program during the past fifteen years have not observed anoxic conditions in Skaha Lake (Jensen 2002, personal communication). However, it is not known when, where and how often their observations were made.

Vaseux Lake

In Vaseux Lake, average secchi depth was 3.6 m with maximum and minimum depths of 4.1m and 3.2 m respectively (Figure 4b). The maximum surface temperature was 23 °C, in August.

Vaseux Lake began to stratify in May with the epilimnion forming at about 4m (Figure 6a). The maximum depth of Vaseux Lake is about 24 meters. During the months of June, July, and August, the epilimnion descended progressively from 8m to 22m causing unsuitable conditions for juvenile sockeye as the hypolimnion decreased concurrently (Figures 6b-d). The June, July, and August thermocline were at 12m, 15m, and 22m respectively. The lake was stratified in September with the epilimnion at a depth of 20m and the thermocline at an estimated 22m (Figure 6e). The lake was isothermal during October and November (Figures 6f and g).

May dissolved oxygen levels ranged from 9.2-5.0 mg/L and were suitable for fish to depths of 24m, beyond which conditions were anoxic (Fig. 6a). In June, July, August, and September, dissolved oxygen levels ranged between 9.5-5.0 mg/L and were suitable for fish to depths of 16m, 10m, 20m, and 18m respectively (Figures 6b-e). However, temperature levels were not suitable for juvenile sockeye during this period. These profiles were typical of a clinograde curve suggesting waters of high productivity (Horne & Goldman 1994). For October and November dissolved oxygen conditions averaged 10.7 and 11.3 mg/L respectively (Figures 6f and g).

Osoyoos Lake

The average secchi depth at the four Osoyoos Lake sites was 3.5m. Sites 1 and 2 are located in the north basin of Osoyoos Lake. Site 3 is located in the central basin, and site 4 is located in the south basin. The maximum was 5.25m and minimum 2.35m both in site 4 (Figure 4c). Maximum surface temperatures occurred in August and were 21.9 °C, 22.2 °C, 23.8 °C, and 24.3 °C for sites 1, 2, 3, and 4 respectively.

The lake was beginning to stratify at all sites in May when temperatures ranged from 20.9-8.0 °C (Figures 7a-d). Particulars for each site are as follows: site 1, in the months of June, July, August and September, the lake was stratified with the epilimnion to depths of 12m, 12m, and 20m and the thermocline at 16m, 16m, and 24m respectively (Figures 7e, l, and m).

At site 2, in the months of June, July, August and September, the lake was stratified with the epilimnion to depths of 12m, 14m, 12m, and 14m and the thermocline at 16m, 18m, 16m, and 18m respectively (Figures 7f, j, n, and r).

At site 3, the epilimnion went to depths of 6m, 8m, 10m, and 14m for June, July, August and September and the thermocline at 10m, 12m, 14m, and 18m respectively (Figures 7g, k, o, and s).

At site 4, the lake became stratified but temperatures remained very warm with lake bottom temperatures of 12.3 °C in June increasing to 14.5 °C in August (Figures 7h, l, and p). The epilimnion was 12m, 10m, and 12m for June, July and August and the thermocline at 14m, 10m, and 14m respectively. At site 4 in September, isothermal conditions were developing with warm 21.2 °C surface, and 18 °C bottom temperatures (Figure 7t). In October and November isothermal conditions were evident as temperatures averaged about 10 °C and 7 °C respectively (Figures 7x and bb).

Sites 1 and 2 in June, July, and August dissolved oxygen levels were suitable for juvenile *O. nerka* at all depths (Figures 7e, f, i, j, m, and n). The oxygen profiles from June to September for sites 1 and 2 progressed from a slight clinograde curve to a clinograde curve suggesting increasing productivity in the epilimnion (Horne & Goldman 1994). Anoxic conditions began to occur below 16m in September (Figures 7q, r). At site 3, summer observations revealed some anoxic conditions extending to all depths below 10m in June and at all depths below 16m in September (Figures 7g, k, o, and s). At site 4, an inversion of dissolved oxygen levels occurred in May where levels generally increased with decreasing depth. At about 20m below surface levels began to decrease again (Figure 7d). In June, July, August, and September anoxic conditions occurred below depths of 12m, 10m, 14m, 20 m respectively (Figures 7h, l, p, and t). Summer oxygen profiles at sites 3 and 4 were typical of waters of high productivity in the epilimnion (Horne & Goldman 1994). October and November dissolved oxygen levels stayed consistent at 9.0-13.0 mg/L at all sites (Figures 7u-bb).

Zone of Tolerance

Figs 8a through 8h show the zone of tolerance for all the sites of the three lakes based on maximum temperature (17 °C) and minimum dissolved oxygen (4 mg/L) tolerances for juvenile *O. nerka* (Rankin 2001, personal communication). This area is an approximation of the suitable vertical habitat available for juvenile sockeye in the pelagic zone. The suitable area is the space between the two lines in the figs. No suitable vertical habitat is predicted if the temperature tolerance line and dissolved oxygen tolerance line meet or cross.

Skaha Lake sites 1, 2, and 3 had conditions suitable for juvenile *O. nerka* throughout the monitoring period. During the month of August, site 1 had approximately 3m of suitable habitat available. The extent of suitable habitat at site 2 is unclear as dissolved oxygen determinations indicated 8.2 mg/L even at 28m. Nevertheless, during August, measurements for site 1 indicate that oxygen was not limiting for juvenile *O. nerka* to depths of 45m (9.0 mg/L). This is also likely for site 2 as sites 1 and 2 are located in the same basin. In addition, the provincial agency in the past fifteen years has not measured anoxic conditions in Skaha Lake (Jensen 2002, personal communication). It is not known when and where their measurements are taken. Nevertheless, in the month of August, site 2 likely had about 20m of suitable habitat for juvenile *O. nerka* in the hypolimnion.

The extent of suitable habitat at site 3 is also uncertain. Temperature limitations in August extended to depths of 28m where the dissolved oxygen reading was 8.8 mg/L. If there were no dissolved oxygen limitations below 28m, there would be approximately 10m of suitable hypolimnion at site 3. This assumption was also applied to other months when there were no oxygen limitations at the lowest depths measured.

At Vaseux Lake there was unsuitable temperature and dissolved oxygen conditions for juvenile *O. nerka* during July-September.

In Osoyoos Lake, September was the most critical month at both Sites 1 and 2 where it is estimated that only about 2 vertical meters of hypolimnion were available. Meanwhile at Site 3 conditions were unsuitable during August and September, and at Site 4 they were unsuitable during July-September. In addition, October sampling in Osoyoos Lake

did not occur until November 1, 2001. This suggests the possibility that the duration of the 2m of vertical habitat available during September may have also included the month of October.

During 2001, Skaha Lake, in terms of temperature and oxygen limits, had the greatest amount of suitable habitat for rearing juvenile *O. nerka*. Vaseux Lake had no suitable habitat and Osoyoos Lake had suitable habitat only in the north basin at sites 1 and 2. Since the data from a single day of sampling is used to represent conditions over the entire month, the duration of temperature and oxygen limitations are not known. However, the size of the lakes, diurnal fluctuations of temporal or oxygen levels is unlikely. When comparing Skaha to current juvenile sockeye rearing conditions (north basin of Osoyoos Lake), temperature and oxygen conditions are likely not an issue in Skaha Lake.

3.2.2 Water Chemistry

Skaha Lake

Total Nitrogen levels averaged 0.21mg/L during February at all three sites and depths ranging between 0.19 – 0.21mg/L (Figure 9a-c). In May, nitrogen concentrations averaged 0.22mg/L and ranged between 0.20-0.25mg/L for all depths. In the summer (June-August), total nitrogen concentrations averaged 0.26mg/L in the epilimnion. Site 3 varied most ranging between 0.20-0.42mg/L. The average for the 20m and deep sections (>36m) averaged 0.20mg/L.

Dissolved nitrogen (Nitrate-Nitrogen) levels were at, or just above the detection limit (0.002mg/L) for 0-10m and 20m samples in February and May-September (Figure 10a and b). As in Okanagan Lake, these low concentration levels may be due to photosynthetic biological uptake with limited mixing between the epilimnion and the hypolimnion and therefore resulting in limited replenishment of nutrients from the hypolimnion into the epilimnion. These low concentration levels suggest that the dissolved nitrogen limitation for phytoplankton throughout Skaha Lake from May-September create conditions favourable for blue-green algae, a less desirable food source for zooplankton (Andrusak et al. 2001). Site 3 at the 20m depth averaged 0.01mg/L for June and July (Fig. 10b). In the deeper samples (>36m), nitrate-nitrogen concentrations were at or just above the detection limit for February and May (Figure 10c). During the summer months the average increased to 0.029 mg/L. In September, the deeper sections increased at sites 1-3 by 0.025, 0.046, and 0.058 mg/L respectively.

Total phosphorus levels averaged 0.011mg/L in the month of February and May samples for all three sites and depths (Figures 11a- c). From May-September the epilimnion was relatively stable, averaging about 0.01mg/L except at Site 3 which had May and September readings of, respectively, 0.003, and 0.019mg/L. The 20m levels and deep sections (>36m) did not differ greatly from those of the epilimnion.

There were no major differences in total dissolved phosphorus concentrations between the epilimnion, the 20m and deep section (>36m) from May-September when all three sites averaged 0.0053mg/L, 0.0037mg/L, and 0.0063mg/L respectively (Figures 12a-c).

Vaseux Lake

In May, total nitrogen levels averaged 0.23mg/L at all three sites (Figure 9d). During the summer months (June-August) the total nitrogen levels for the epilimnion was 0.23mg/L. In the summer months, it increased at the 15 m depth to 0.44mg/L and to 0.6mg/L at >18 m.

Conditions in Vaseux Lake were similar to those of Skaha Lake where nitrate-nitrogen levels for 0-10 m samples averaging at the low detection limit of 0.002mg/L (Figure 10d). Nitrate-nitrogen concentrations at the 15m and >18 m depths averaged 0.151mg/L for May-September. Low concentrations were detected in May, and increased through the summer, and decreased again in September.

During May-September total phosphorus levels in the epilimnion averaged 0.015mg/L, while samples at the 15m and >18m depths averaged 0.096mg/L and 0.15mg/L respectively (Figure 11d). This difference is likely the result of the thermal stratification, biological productivity, and limited mixing between the epilimnion and hypolimnion (Horne & Goldman 1994). A similar trend was found in total dissolved phosphorus in the epilimnion, 15m, and >18m strata with increasing average concentrations of 0.006mg/L, 0.08mg/L, and 0.116mg/L respectively (Figure 12d).

Osoyoos Lake

Total nitrogen concentrations averaged 0.34mg/L for March for all sites and depths (Figure 9e, f and g). Site 2 averaged 0.26mg/L at all depths from May-August. For sites 3 and 4 the nitrogen levels increased with depth from averaging 0.27mg/L in the epilimnion and increasing to 0.44mg/L in the hypolimnion. Sites 2, 3, and 4 also had similar values to those of the upper lakes where nitrate-nitrogen levels in the epilimnion were near the lower detection limit of 0.002mg/L from May-September (Figure 10e, f, and g). However, Site 1 in September had higher readings of 0.01mg/L. Site 2 had increasing concentrations of nitrate at the 20m and deep section samples ranging from 0.007mg/L and 0.014mg/L in May to 0.092mg/L and 0.167mg/L in September respectively.

The total phosphorus levels in the epilimnion were relatively stable from May to September averaging about 0.015mg/L (Figures 11e, f, and g). From May to September there was a trend towards increasing levels in the 20m and deep section samples for sites 2, 3, and 4. A similar trend was also found with total dissolved phosphorus averaging about 0.005mg/L (Figures 12e, f, and g). In addition, from May to September there was a trend of increasing concentrations for the 20m and deep section samples for sites 2, 3, and 4. This is most likely due to the stratification and biological productivity in the epilimnion (Horne & Goldman 1994).

Nitrogen:Phosphorus Ratios

In most lakes there is a direct relationship between the concentration of the limiting nutrient and phytoplankton (Horne & Goldman 1994). Phosphorus is usually the limiting nutrient as most living matter requires a TN:TP ratio of 16:1 (Horne & Goldman 1994). This can be further refined to: TN:TP>15, phosphorus limiting, TN:TP<10, nitrogen limiting, TN:TP between 10 and 15, then it is neither, or both limiting (Wetzel 1983, Andrusak et al. 2001).

A measure of the available nutrients is the amount of dissolved nitrogen and phosphorus available to phytoplankton in the epilimnion (Andrusak et al. 2001). Using a ratio of 7:1 for nitrates to dissolved phosphorus ($\text{NO}_3\text{:TDP}$) is often used. If the ratio is <7 , then conditions are more favourable for cyanobacteria (blue-green algae) which is not dissolved nitrogen dependent and can fix the inorganic form of nitrogen, and if >7 , then conditions are favourable for other phytoplankton such as diatoms. This is relevant in that blue-green algae are a poor food source for zooplankton (Andrusak et al. 2001).

At all Skaha Lake sites the TN:TP ratios were greater than 15 suggesting that the lake is phosphorus limited (Figure 13a). Considering the available dissolved nutrients ($\text{NO}_3\text{:TDP}$), the $\text{NO}_3\text{:TDP}$ ratios were all <7 which suggests an environment favourable to blue-green algae (Figure 14a).

For Vaseux Lake, other than May, the TN:TP ratio was less than 10 suggesting nitrogen limitation (Figure 13b). The $\text{NO}_3\text{:TDP}$ ratio were <7 suggesting conditions favourable for blue-green algae (Figure 14b).

For Osoyoos Lake, average TN:TP ratios were either just above 15 or between 10-15 (Figure 13c). This suggests that the lake was either phosphorus limiting or when between a ratio of 10-15 either, neither or both may be limiting. Of note is that site 3 (central basin) had measurements less than 10, suggesting nitrogen limitation, and that would have decreased the TN:TP ratio of the lake as a whole. For $\text{NO}_3\text{:TDP}$ ratios, they were all less than 7 suggesting conditions favourable for blue-green algae (Figure 14c).

Chlorophyll *a*

Chlorophyll *a* is often used as an indicator of phytoplankton standing crop (Horne & Goldman 1994). The May-September chlorophyll *a* in Skaha Lake, the average was $1.43 \mu\text{g/L}$ (Figure 15a). From May-September, for Vaseux and Osoyoos Lakes, the averages were $1.54\mu\text{g/L}$ and $2.92\mu\text{g/L}$ respectively (Figure 15b and c). An increase in phosphorus concentrations would be expected to produce an increase in chlorophyll *a* concentrations. This is not seen in Vaseux Lake and may be due to the nitrogen limitation and conditions favourable for cyanobacteria. A positive relationship between an increase in total phosphorus to an increase in chlorophyll *a* can be seen for Okanagan, Skaha and Osoyoos Lakes (Figure 17).

Silica

Silica is used by diatoms for their rigid cell walls, called a frustules and it accounts for their success (Horne & Goldman 1994). Diatoms are also a preferred food source for zooplankton (Horne & Goldman 1994). Silica levels in all Skaha Lake sites averaged 5.11mg/L (Figure 16a). Those in Vaseux Lake averaged 7.8mg/L and Osoyoos Lake 7.09mg/L (Figure 16b and c). Silica levels were higher at sites 3 (central basin) and 4 (south basin) than in the north basin. Silica does not seem to be limiting diatom production in any of these lakes as concentrations of silica did not fluctuate greatly.

3.3 Macrozooplankton

Zooplankton results are summarized in Figures 18-21. The zooplankton found in Skaha Lake, Vaseux Lake, and Osoyoos Lake were Cyclopoids, Bosmina, Daphnia, Epischura, Diaptomus, Rotifers, Leptodora, Nauplius, Sida, Diaphanosoma, Chironomids and *Mysis relicta*.

Information from on the north basin of Osoyoos Lake was also included as it was recently determined that the central and south basins are likely not suitable for juvenile *O. nerka* rearing because of temperature and dissolved oxygen limitations (Hyatt & Rankin 1999). Average zooplankton densities and biomass, mean lengths, and size composition were all from the growing season averages (May-November). *Mysis relicta* information from the separate vertical hauls was used in place of that from the zooplankton vertical hauls. Differences between Skaha Lake rearing potential and current rearing conditions in the north basin of Osoyoos Lake will be discussed

The Pacific Biological Station (PBS) lab found that in terms of density of specimens and biomass Cyclopoids and Diaptomids to be the major macrozooplankton for Skaha Lake and the north basin of Osoyoos Lake (Figures 18, 19). In addition to Daphnia, they were also the major macrozooplankton for the central and south basin of Osoyoos Lake. In Vaseux Lake, Cyclopoids, Diaptomids, and Daphnia were the major zooplankton in terms of density and biomass. The dominant cladoceran in Skaha Lake, Vaseux Lake, and all basins of Osoyoos was the Daphnia although there were among lake differences in density and biomass. Daphnia density and biomass decreased when *O. nerka* or *Mysis relicta* exerted grazing pressures on them.

Densities and biomass of cladocerans in both Skaha Lake and the Osoyoos north basin were lower than in Vaseux Lake and the central and south basins of Osoyoos Lake, most likely because of grazing pressures from *O. nerka* and *Mysis relicta*. Skaha Lake had similar but slight higher, density and biomass of zooplankton, than did the north basin of Osoyoos Lake.

Mean lengths of zooplankton were generally greater in Skaha Lake than in the north basin of Osoyoos Lake, although this was not a statistically significant difference (Figure 20). Average lengths of Daphnia, Cyclopoida, Diaptomids, and Leptodora in Skaha Lake, Vaseux Lake, and the central and south basins of Osoyoos Lake were all greater than those of the north basin of Osoyoos Lake.

Zooplankton of Skaha Lake, Vaseux Lake, and the central and south basins of Osoyoos Lake all were larger and had greater densities between 0.9-1.5mm when compared with those of the north basin of Osoyoos Lake (Figure 21). This is also likely due to the selective grazing pressures of the juvenile sockeye.

3.4 *Mysis Relicta*

Mysis relicta was extremely rare in Vaseux Lake and the central and south basins of Osoyoos Lake so size comparisons were made only between specimens from Skaha Lake and the north basin of Osoyoos Lake (Figures 18, 19).

Overall the density, biomass, and mean length of *Mysis relicta* were greater in Skaha Lake than in the north basin of Osoyoos Lake (Fig. 22, 23). Table 3 summarizes the seasonal data.

Table 3. Summary of seasonal average density, biomass, and mean length of *Mysis relicta* from Skaha Lake and the north basin of Osoyoos Lake, 2001

	Density (No./m ²)	Biomass (mg/m ²)	Mean Length (mm)
Skaha	131.56	946.06	12.99
Osoyoos	51.64	246.78	10.50

They were at peak densities in May and numbers decreased through the growing season. In contrast, *Mysis relicta* in the north basin of Osoyoos Lake reached peak densities in July and then decreased to November. Differences in mean lengths were greatest in May and decreased as the growing season progressed (Figure 24). In both lakes *Mysis relicta* mean lengths increased through the growing season.

Initial May biomass of Skaha Lake *Mysis relicta* was greater than in the north basin of Osoyoos Lake (Figure 25). It peaked in August then decreased to November. The north basin of Osoyoos Lake biomass increased from May to July after which it remained relatively constant through October but had fallen off by the time of November sampling.

4.0 DISCUSSION/CONCLUSIONS

Based on data collected during the 2001 sampling season and on the relationship between total dissolved phosphorus and total biomass of limnetic juvenile *O. nerka*, the rearing capacity for 86mm and 100mm *O. nerka* smolts in Skaha Lake is estimated to be 2,781 smolts/ha and 1,977 smolts/ha respectively. For Vaseux Lake, the rearing capacity for 86mm and 100mm is estimated to be 3,047 smolts/ha and 2,167 smolts/ha. For Osoyoos Lake, the rearing capacity for 86mm and 100mm is estimated to be 2,981 smolts/ha and 2,119 smolts/ha. Skaha Lake and Osoyoos Lake have similar rearing potential based on this relationship.

The carrying capacity of Osoyoos Lake as calculated by Hyatt and Rankin (1999) was estimated to be higher even though similar concentration levels of total phosphorus were used. The main reason for this difference is the data used to develop the relationship of total phosphorus to fish biomass. The data used in Hyatt and Rankin (1999) used a greater range of lake trophic conditions that ranged from <2µg/L-300µg/L of total phosphorus while the lake trophic conditions used in Figure 2 of this report ranged from <2µg/L-30µg/L. Another difference is that the lakes used in Hyatt and Rankin (1999) were not limited to lakes containing only *O. nerka*. Figure 2 from this report used lakes whose major limnetic fish species was *O. nerka* and some of the lakes used also contained *Mysis relicta*. The relatively unknown impacts of *Mysis relicta* on the rearing production of sockeye or kokanee lakes may have some influence. The main outcome of these differences is a more conservative rearing estimate. Nevertheless, the value is in comparing the lakes rearing capacity and demonstrating that Skaha and Osoyoos Lakes are similar in their total phosphorus levels for 2001. Since Osoyoos Lake has a demonstrated capacity to sustain a relatively large amount of juvenile sockeye, this suggests that the rearing capacity of Skaha Lake is not limited.

Secchi depths related well with the productivity of Skaha Lake, Vaseux Lake and Osoyoos Lake decreasing in depth with increases to phosphorus concentrations. Skaha Lake, in terms of temperature and oxygen limits, had the greatest amount of preferable habitat for rearing juvenile *O. nerka*. Vaseux Lake had no suitable habitat and Osoyoos with suitable habitat only in the north basin (sites 1 and 2). This is based on the

assumption that the sample day is representative of the particular month. The duration of the temperature and oxygen limits cannot be determined from the data as it is assumed that one day of data is representative of the conditions for a particular month. On the basis of the current somewhat marginal rearing conditions for sockeye in the north basin of Osoyoos Lake, and the comparatively favourable circumstances in Skaha Lake, temperature and oxygen conditions are likely not an issue in Skaha Lake.

The total nitrogen to total phosphorus (TN:TP) ratio suggests that Skaha Lake and the north basin of Osoyoos Lake are phosphorus limited while Vaseux Lake is nitrogen limited. At site 3 in Osoyoos Lake the TN:TP ratio suggests that the central basin is initially phosphorus limited in spring, but becomes nitrogen limited in summer. At Site 4 the TN:TP ratio suggests that the south basin is either phosphorus or nitrogen limited, or both, but is most likely phosphorus limited.

All of the lakes had a dissolved TN:TP ratio less than 7 meaning that conditions are thought to be favourable for cyanobacteria. The north basin of Osoyoos Lake and Skaha Lake are quite similar so one might expect that the conditions for sockeye in Skaha Lake would not be very different from the current rearing conditions in the north basin of Osoyoos Lake.

The relationship of an increase in total phosphorus to an increase in chlorophyll *a* can be seen for Okanagan, Skaha and Osoyoos Lakes. This is not seen for Vaseux Lake data and may be due to the nitrogen limitation and conditions favourable for cyanobacteria. Silica levels did not vary greatly which suggests that it is not limiting.

Cyclopoids and Diptomids were the dominant macrozooplankton in Skaha Lake, Vaseux Lake, and Osoyoos Lake. Daphnia were also the dominant macrozooplankton in Vaseux Lake and the central and south basins of Osoyoos Lake. A major difference in zooplankton occurs in lakes where juvenile *O. nerka* or *Mysis relicta* are present e.g. in Skaha Lake and the north basin of Osoyoos Lake where daphnia occurred in lower densities and biomass than in lakes without them. A difference between Skaha Lake and the north basin of Osoyoos Lake is that the mean lengths of zooplankton, and densities of the 0.9-1.5mm zooplankton, were generally greater in Skaha Lake. This can be attributed to the presence of more juvenile *O. nerka* than *Mysis relicta* in the north basin of Osoyoos Lake compared to the more *Mysis relicta* than *O. nerka* in Skaha Lake. Overall, there were no significant differences between Skaha Lake and the north basin of Osoyoos Lake in terms of zooplankton, other than *Mysis relicta*.

Mysis relicta was not numerous in Vaseux Lake and the central and south basins of Osoyoos Lake and most likely because of the short residence time of Vaseux Lake waters and the temperature and oxygen limitations in the central and south basins of Osoyoos Lake.

Mysis relicta were found in Skaha Lake and the north basin of Osoyoos Lake. Skaha Lake had greater density, biomass and mean lengths of organisms when compared to the north basin of Osoyoos Lake.

This is an issue as there is considerable circumstantial evidence that in some lakes an increase in *Mysis relicta* coincides with a decrease in the kokanee populations (Nesler & Bergersen 1991). This has been studied in Okanagan Lake recently.

Mysis relicta was first proposed to be introduced into Okanagan Lake (immediately upstream of Skaha Lake) as a food source for lake whitefish (*Coregonus clupeaformis*) in 1939 (Clemens et al. 1939, Northcote 1991). Approximately 25 years later, *Mysis relicta* were intentionally introduced into the Okanagan in 1966 as a food source for kokanee (Andrusak et al. 2001). *Mysis relicta* establishment into Okanagan Lake has coincided with the decrease in the kokanee population, although there was a temporary increase in the kokanee size, through the 1970's, 1980's, and the 1990's.

In response to this decline the Ministry of Water, Land, and Air Protection (MoWLAP) Fisheries Branch identified a need for a "Comprehensive, interdisciplinary, long term Action Plan to ameliorate and rebuild wild kokanee" (Ashley et al. 1998, Page ii). A workshop was held in 1995 of experts and the public. It was identified that the carrying capacity of Okanagan Lake has decreased and degradation of spawning habitat both contributed to the decline in the kokanee population. *Mysis relicta* competition with kokanee for zooplankton was also identified as a contributor to this decline as *Mysis relicta* abundance has coincidentally increased. Following this workshop, five years of studies and monitoring on Okanagan Lake similar to this study have been conducted to better understand the whole lake biological relationships.

After five years of study, still little is known as to the interactions between *Mysis relicta*, *O. nerka*, and zooplankton and their roles in the food web in Okanagan Lake. A nutrient imbalance and competition with *Mysis relicta* (opossum shrimp) is still being postulated as causing low in-lake survival and limiting salmonid production for Okanagan Lake (Andrusak et al. 2001, MS).

The evidence that *Mysis relicta* has negatively impacted kokanee populations of Okanagan Lake is mainly circumstantial. Understanding the interactions of *M. relicta*, *O. nerka* and zooplankton is complex. From 1989 and 1998 there has been a slight decrease in *Mysis relicta* densities in Okanagan Lake (McEachern 1999, MS). This has coincided with the similar decreases in kokanee abundance that suggest *Mysis relicta* are not the only factor for the kokanee decline. Another large lake within the Okanagan Basin is Kalamalka Lake. It has greater densities of *Mysis relicta* with a stable population of kokanee with similarities in limnology and basin morphometry. A study looking at both lakes suggested that *Mysis relicta* competition for zooplankton cannot alone be attributed to the decline in Okanagan kokanee but they clearly compete with planktivorous fish for zooplankton (Wahl & Lasenby 2000, MS). In addition, introduction of *Mysis relicta* to Wood Lake was unsuccessful. There are also coastal lakes in western North America that have populations of *Neomysis mecredis*, though a different genus and species, with populations of *O. nerka* considered being stable. Ultimately, the impacts associated with *Mysis relicta* shrimp are complex and there will not be a simple answer or solution to this complex problem unless more is known of their interaction with *O. nerka* and zooplankton.

It is generally agreed that once *Mysis relicta* is established in a lake system, it is virtually impossible to completely remove them (Northcote 1991). Some of the problems with *Mysis relicta* introductions include predation on zooplankton, direct and indirect effects on phytoplankton, effects on fish, upper trophic level implications, eutrophication implications, pollution implications, and parasite implications (Northcote 1991). *Mysis relicta* interactions with *O. nerka* and zooplankton are often regulated by different factors on its potential effects on an ecosystem. Factors include thermal barriers, entrainment factors, control of lake trophic status, and biological controls such as an efficient

predator on *Mysis relicta* (Northcote 1991). In addition, it has been suggested that dissolved oxygen concentrations in the hypolimnion may influence *Mysis relicta* impacts by inhibiting vertical migration (Hyatt 2001, personal communication).

Data have shown that sockeye production in Osoyoos Lake is currently limited primarily by low numbers of spawners but there is evidence that Osoyoos Lake would become limiting to overall production before the Okanagan River spawning grounds (Hyatt & Rankin 1999). Other factors that affect salmonid production to Okanagan sockeye are dams (upstream and downstream losses), loss of habitat, temperature barriers and low winter flows (Bull 1999). *Mysis relicta* are present in low numbers (about 10% of Okanagan Lake *Mysis relicta* biomass) and may be increasing (Hyatt 2001, personal communication). This would be a concern for the Okanagan Nation and Fisheries and Oceans Canada (DFO) if *Mysis relicta* potentially affect sockeye populations, as has happened in Okanagan Lake (the coinciding downward trend of juvenile *O. nerka* with the increase of *Mysis relicta* population) (Hyatt 2001, personal communication).

In addition, as kokanee populations are depressed in Skaha Lake, it is unknown how the reintroduction of sockeye will affect the current ecosystem. Reintroduction will be an issue if the low kokanee population is determined to be due to in-lake issues and rearing capacity is limiting.

Literature shows that *Mysis relicta* impact *O. nerka* but it is still relatively unknown of the exact impact of the *Mysis relicta* / *O. nerka* / zooplankton interactions in Skaha and Osoyoos Lakes. More work to increase knowledge on the interactions between *Mysis relicta*, *O. nerka*, and zooplankton is required.

Physical, chemical, and zooplankton features of Skaha Lake suggest that it has similar or better conditions for rearing Okanagan sockeye than those presently being used. However, *Mysis relicta* are in greater abundance in Skaha Lake than in the north basin of Osoyoos Lake. Several questions arise from the first year of lake rearing assessment:

1. Why is the Kokanee population in Skaha Lake smaller than historically?
2. What part, if any has *M. relicta* played in the decline in Skaha Lake kokanee numbers?
3. What are the dynamics of *O. nerka*-*Mysis relicta* – zooplankton interactions in Skaha Lake?
4. How would these interactions affect the success of any re-introduction of sockeye and the present kokanee population in Skaha Lake?

5.0 RECOMMENDATIONS

To help answer the foregoing questions, another year of physical limnology, water chemistry, zooplankton and *Mysis relicta* abundance sampling and comparison of Skaha Lake and the north basin of Osoyoos Lake is recommended. Extensive sampling on Vaseux Lake and the central and south basin of Osoyoos Lake is not considered useful because of the temperature and oxygen limitations to rearing potential. The main objectives in year 3 of the Evaluation of Re-introduction of Sockeye into Skaha Lake project in regards to assessment of rearing conditions are to expand information on the Skaha Lake kokanee population and rearing behaviour of *O. nerka* in the north basin of Osoyoos Lake. To achieve this, the following information will be needed.

1. A compilation of all available Skaha Lake kokanee information to begin to identify information gaps.
2. Compare historical years of predicted versus observed kokanee population numbers for Skaha Lake using the total phosphorus to fish biomass relationship to verify relationship.
3. Continue revised monthly water quality sampling (physical and chemical) of Skaha Lake (two sites) and the north basin of Osoyoos Lake (two sites). Revisions to the 2001 sampling plan are:
 - Measure temperature/oxygen profiles at or near lake-bottom at all sites.
 - During June-September on Skaha and Osoyoos Lakes when temperature and dissolved oxygen conditions for juvenile *O. nerka* habitat become critical, increase the frequency of sampling at the sample sites (two additional sampling periods).
 - Measure Vaseux Lake temperature and oxygen over the summer.
4. Biweekly *Mysis relicta* and zooplankton sampling. Sampling methodology used in 2001 is recommended with the exception that no replicates need be taken.
5. Collection of kokanee information from Skaha Lake including juvenile monitoring, diel migration monitoring (in conjunction with *Mysis relicta*), and growth rates of maturing kokanee. This can be accomplished by:
 - Hydroacoustic and trawl surveys to determine juvenile abundance. Fisheries and Oceans Canada is already conducting this work.
 - Seasonal gill netting to collect biological information (age structure, growth rates, sex, diet analysis, and genetic analysis).
 - Diel migration monitoring over a 24-hour period to determine *Mysis relicta*/kokanee interaction in Skaha Lake.
6. Collection of juvenile sockeye information including juvenile monitoring, diel migration monitoring (in conjunction with *Mysis relicta*), and estimation of littoral presence in Osoyoos Lake is recommended.
 - Hydroacoustic and trawl survey work to determine juvenile abundances. Fisheries and Oceans Canada is already conducting this work.
 - Beach seining of the littoral zone after emergence of *O. nerka* to determine length of littoral residence.
 - Diel migration monitoring over a 24-hour period and trawling to determine *Mysis relicta*/sockeye interaction and growth and diet of juvenile *O. nerka* in the north basin of Osoyoos Lake.

6.0 BIBLIOGRAPHY

- Andrusak, H., S. Matthews, I. McGregor, K. Ashley, G. Wilson, D. Sebastian, G. Scholten, L. Vidmanic, J. Stockner, K. Hall, G. Andrusak, J. Sawada, D. Cassidy & J. Webster. 2001. Okanagan Lake Action Plan Year 5 (2000) Fisheries Project Report RD 89, Fisheries Management Branch, Ministry of Water, Land and Air Protection, Province of British Columbia, Victoria.
- Andrusak, H., D. Sebastian, I. McGregor, S. Matthews, D.L. Smith, K. Ashley, S. Pollard, G. Scholten, J. Stockner, P. Ward, R. Kirk, D. Lasenby, J. Webster, J. Whall, G. Wilson & H. Yassien. 2000. Okanagan Lake Action Plan Year 4 (1999) Fisheries Project Report RD 83, Fisheries Management Branch, Ministry of Agriculture, Food and Fisheries, Province of British Columbia, Victoria.
- Ashley, K., B.G. Shepherd, D. Sebastian, L. Thompson, L. Vidmanic, P. Ward, H. Yassien, L. McEachern, R. Nordin, D. Lasenby, J. Quirt, J. Whall, P. Dill, E. Taylor, S. Pollard, C. Wong, J. den Dulk & G. Scholten. 1998. Okanagan Lake Action Plan Year 1 (1996-97) and Year 2 (1997-98) Fisheries Project Report RD 73, Fisheries Branch, Ministry of Environment, Lands and Parks, Province of British Columbia, Victoria.
- Bull, C. 1999. Fisheries Habitat in the Okanagan River. Phase 1: Options for protection and restoration. pp. 61 pp., Glenfir Resources, Penticton.
- Clemens, W.A., D.S. Rawson & J.L. McHugh. 1939. A biological survey of Okanagan Lake, British Columbia. pp. 70 pp. Fisheries Research Board of Canada, Ottawa.
- Downing, J.A., C. Plante & S. Lalonde. 1990. Fish Production Correlated with Primary Productivity, not the Morphoedaphic Index. Canadian Journal of Fisheries and Aquatic Sciences 47: 1929-1936.
- Hanson, J.M. & M.F. Leggett. 1982. Empirical Prediction of Fish Biomass and Yield. Canadian Journal of Fisheries and Aquatic Sciences 39: 257-263.
- Horne, A.J. & C.R. Goldman. 1994. Limnology. McGraw-Hill, Inc., New York. 576 pp. pp.
- Hyatt, K.D., personal communication. 2001. Research Scientist, Fisheries and Oceans Canada, Nanaimo.
- Hyatt, K.D. & D.P. Rankin. 1999. A Habitat Based Evaluation of Okanagan Sockeye Salmon Escapement Objectives. Canadian Stock Assessment Secretariat 99: 59pp.
- Jensen, V. 2002. Biologist, Ministry of Water, Land and Air Protection.
- Johannes, M.J. 2002. Scientist, Northwest Ecosystem Institute, February 6, 2002.

- McEachern, L. 1999. Trends in Abundance of *Mysis relicta* Over the Past Decade in Okanagan Lake; Implications of Seasonal Variation in Armstrong Arm. pp. 87-100 Okanagan Lake Action Plan Year 3 (1998) Report, Fisheries Management Branch, Ministry of Agriculture, Food and fisheries, Province of British Columbia, Victoria.
- Nesler, T.P. & E.P. Bergersen (ed.). 1991. Mysids in fisheries: hard lessons from headlong introductions. American Fisheries Society Symposium 9.
- Northcote, T. 1991. Success, Problems, and Control of Introduced Mysid Population in Lakes and Reservoirs. pp. 5-16. *In*: E.P. Bergersen (ed.) Mysids in Fisheries: Hard lessons from headlong introductions, American Fisheries Society Symposium 9.
- Rankin, D.P. 2001. Scientist, Department of Fisheries and Oceans Canada.
- Rankin, D.P., B. Hanslit & K.D. Hyatt. 2000. Okanagan lakes mysid sampling guidelines, Data Management Section, Fisheries and Oceans Canada, Nanaimo.
- Sprules, W.G., L.B. Holtby & G. Griggs. 1981. A microcomputer-based measuring device for biological research. Canadian Journal of Zoology 59: 1611-1614.
- Stockner, J. 1987. Lake fertilization: the enrichment cycle and lake sockeye salmon production. Canadian Special Publication of Fisheries and Aquatic Sciences 96: 198-215.
- Wahl, D.H. & D. Lasenby. 2000. Comparison of the Trophic Role of the Freshwater Shrimp *Mysis relicta* in Two Okanagan Valley Lakes, British Columbia. pp. 259-277 Okanagan Lake Action Plan Year 4 (1999), Fisheries Management Branch, Ministry of Agriculture, Food and fisheries, Province of British Columbia, Victoria.
- Wetzel, R.G. 1983. Limnology. Saunders College Publishing, Toronto. 297 pp.

Appendix A

Figures 1 through 23

Figure 1.	Rearing sampling sites
Figure 2.	Total phosphorus – <i>O. nerka</i> biomass relationship
Figure 3.	Length-weight regression for Osoyoos Lake sockeye smolts (1957-2000)
Figure 4a-c.	Secchi depth transparencies 2001
Figure 5a-u.	Temperature/oxygen profiles for Skaha Lake for 2001
Figure 6a-g.	Temperature/oxygen profiles for Vaseux Lake for 2001
Figure 7a-bb.	Temperature/oxygen profiles for Osoyoos Lake for 2001
Figure 8a-h.	Zones of Tolerance for <i>O. nerka</i> in Skaha, Vaseux, and Osoyoos Lake
Figure 9a-g.	Total Nitrogen levels for Skaha, Vaseux, and Osoyoos Lake
Figure 10a-g.	Nitrate-Nitrogen levels for Skaha, Vaseux, and Osoyoos Lake
Figure 11a-g.	Total Phosphorus levels for Skaha, Vaseux, and Osoyoos Lake
Figure 12a-g.	Total dissolved phosphorus levels for Skaha, Vaseux, and Osoyoos Lake
Figure 13a-c.	Total Nitrogen : Total Phosphorus Ratios for Skaha, Vaseux, and Osoyoos Lake
Figure 14a-c.	NO ₃ /TDP ratio at 0 to 10m for Skaha, Vaseux, and Osoyoos Lake
Figure 15a-c.	Chlorophyll <i>a</i> levels at 0-10m for Skaha, Vaseux, and Osoyoos Lakes
Figure 16a-g.	Silica levels for Skaha, Vaseux, and Osoyoos Lake
Figure 17.	Total Phosphorus : Chlorophyll <i>a</i> ratio at 0-10m for Skaha Lake, Vaseux Lake, and Osoyoos Lake
Figure 18.	Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin Zooplankton Community Structure: Species Composition by Density Seasonal Average (May-November)
Figure 19.	Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin Zooplankton Community Structure: Species Composition by Biomass Seasonal Average (May-November)
Figure 20.	Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin Zooplankton Mean Length Seasonal Average (May-November)
Figure 21.	Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin Zooplankton Density by Size Frequency Seasonal Average (May-November)
Figure 22.	<i>Mysis relicta</i> Densities and Mean Length (May-November) in Skaha Lake and North Basin of Osoyoos Lake
Figure 23.	<i>Mysis relicta</i> Biomass (May-November) in Skaha Lake and North Basin of Osoyoos Lake

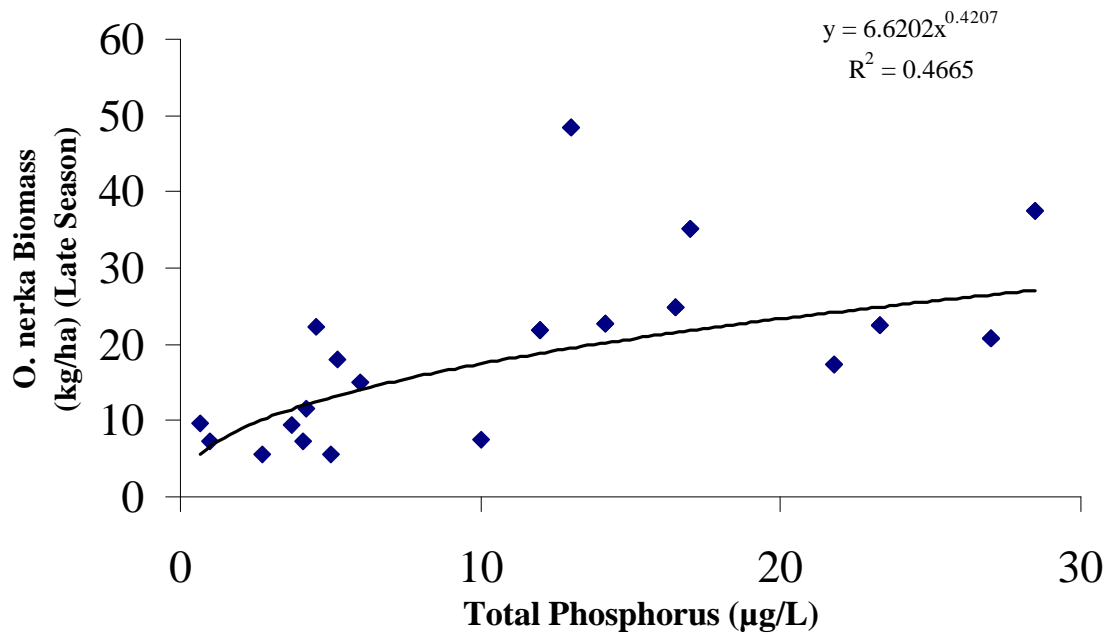


Figure 2: Total phosphorus – O. nerka biomass relationship. Data include biomass and TP estimates from a series of sockeye and kokanee lakes only. These lakes may or also contain Mysis relicta populations. Methods used to derive nerkid biomass estimates include standard acoustic / trawl surveys. For details see Stockner (1987), Hyatt and Rankin (1999)

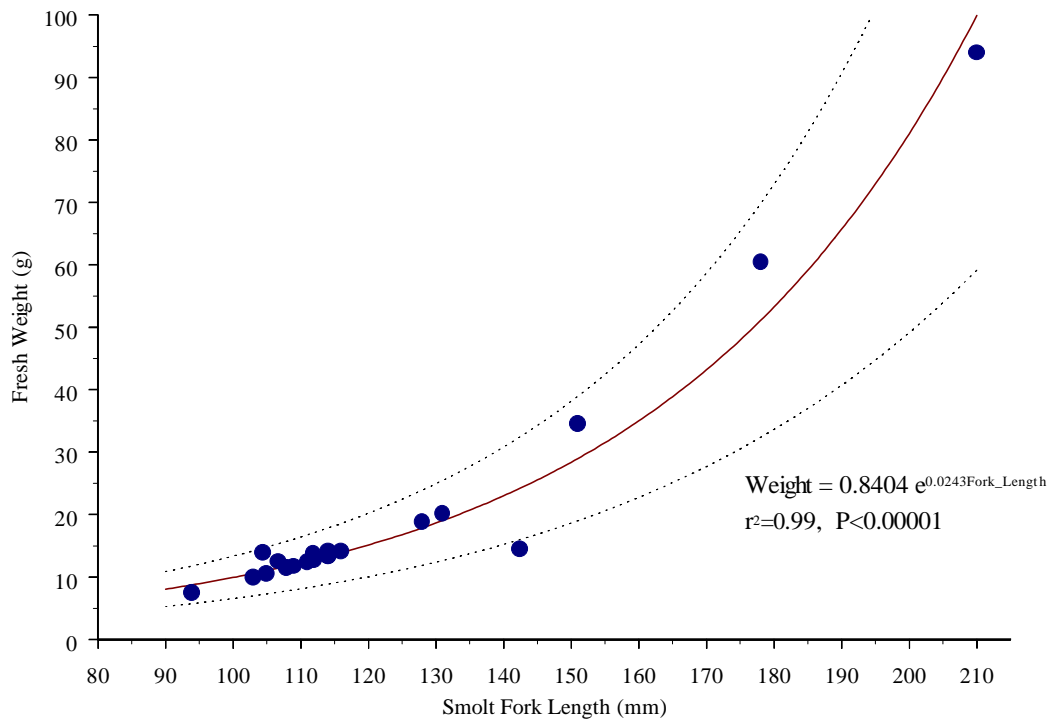


Figure 3: Length - weight regression for Osoyoos Lake sockeye smolts (1957 - 2000).

2001	Site 1	Site 2	Site 3
F			
M			
A			
M	5.6	5.5	5.6
J	4.6	5.2	4.9
J	5.8	5.1	5.8
A	5.3	5.6	6.3
S	4.7	4.5	5.9
O	3.7	4.6	4.7
N			
Average	4.9	5.1	5.5
	Lake average		5.2

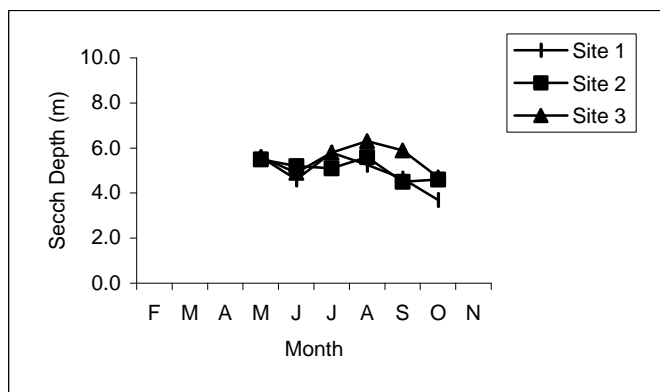


Figure 4a Skaha Lake

2001	Site 1
F	
M	
A	
M	3.7
J	4.1
J	3.6
A	4.0
S	3.5
O	3.3
N	3.2
D	
Average	3.6

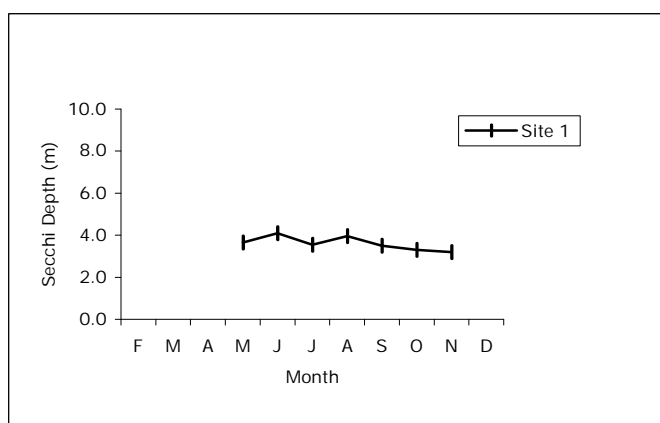


Figure 4b Vaseux Lake

2001	Site 1	Site 2	Site 3	Site 4
F				
M				
A				
M	3.6	3.6	4.4	5.3
J	3.1	3.6	3.6	3.8
J	3.0	4.0	3.3	2.4
A	3.2	2.8	3.7	2.8
S	4.4	4.6	4.7	2.9
O	3.2	3.3	3.3	2.7
N		2.8	2.5	2.7
D				
Average	3.4	3.5	3.6	3.2
	Lake Average		3.5	

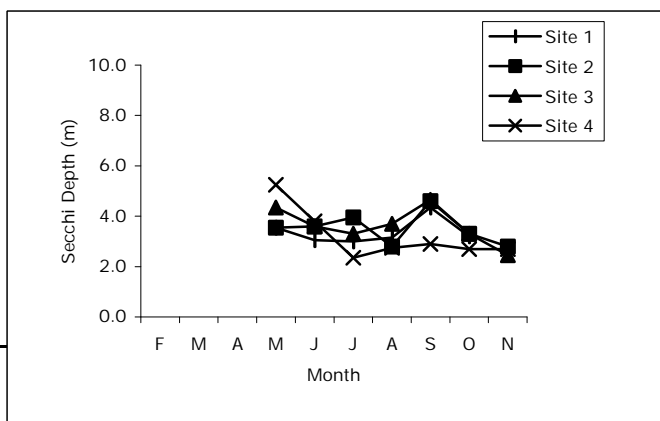


Figure 4c Osoyoos Lake

Figure 4: Secchi Depth Transparencies 2001

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
15.5	0	9.6	0
13.7	2	9.7	2
12.8	4	9.8	4
12.4	6	10.0	6
11.8	8	10.0	8
10.2	10	10.2	10
9.3	12	10.1	12
8.8	14	10.1	14
8.6	16	10.2	16
8.2	18	10.2	18
8.0	20	10.3	20
7.3	24	10.3	24
6.9	28	10.5	28
	32		32
	36		36
	40		40

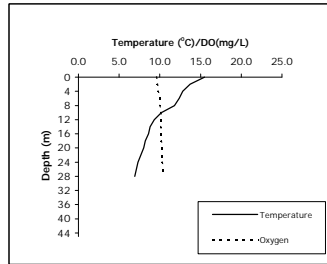


Figure 5a Site 1 May

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
16.5	0	10.1	0
15.9	2	10.3	2
15.7	4	10.4	4
15.5	6	10.5	6
15.4	8	10.5	8
15.3	10	10.6	10
14.9	12	10.6	12
14.7	14	10.6	14
14.4	16	10.5	16
11.9	18	10.3	18
10.9	20	10.4	20
10.4	24	10.3	24
8.8	28	10.7	28
	32		32
	36		36
	40		40

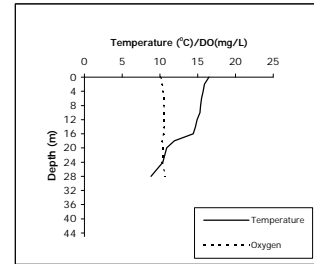


Figure 5d Site 1 June

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
15.5	0	11.3	0
13.6	2	11.6	2
12.9	4	12.0	4
12.3	6	12.3	6
11.8	8	12.4	8
10.4	10	12.3	10
9.6	12	12.3	12
8.6	14	12.3	14
8.0	16	12.4	16
7.6	18	12.5	18
7.8	20	12.2	20
7.0	24	12.3	24
6.6	28	12.1	28
	32		32
	36		36
	40		40

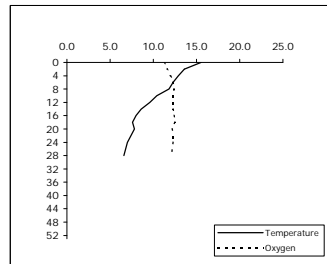


Figure 5b Site 2 May

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
16.2	0	10.1	0
15.7	2	10.4	2
16.6	4	10.5	4
15.5	6	10.6	6
15.4	8	10.6	8
14.8	10	10.5	10
12.4	12	10.4	12
11.4	14	10.3	14
10.7	16	10.4	16
10.2	18	10.4	18
9.7	20	10.6	20
9.1	24	10.8	24
7.9	28	10.9	28
	32		32
	36		36
	40		40

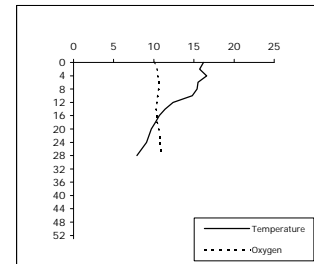


Figure 5e Site 2 June

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
13.0	0	11.9	0
11.8	2	12.2	2
11.2	4	12.3	4
11.0	6	12.4	6
10.5	8	12.4	8
9.2	10	12.3	10
9.0	12	12.4	12
8.8	14	12.4	14
8.4	16	12.3	16
8.2	18	12.3	18
8.0	20	12.5	20
7.6	24	12.2	24
7.2	28	12.7	28
	32		32
	36		36
	40		40

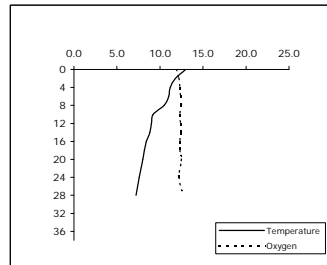


Figure 5c Site 3 May

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
17.3	0	10.4	0
17.2	2	10.4	2
17.1	4	10.5	4
17.0	6	10.6	6
16.8	8	10.6	8
16.8	10	10.6	10
11.6	12	10.3	12
11.0	14	10.6	14
10.2	16	10.5	16
9.9	18	10.6	18
9.8	20	10.7	20
9.5	24	10.7	24
9.0	28	10.7	28
	32		32
	36		36
	40		40

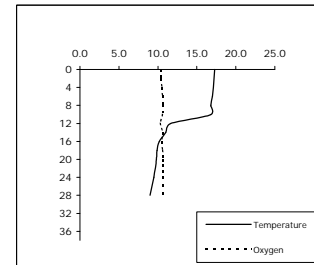


Figure 5f Site 3 June

Figure 5: Temperature/Oxygen Profiles for Skaha Lake for 2001/2002

Temperature	Oxygen
Temp	Depth
19.7	0
19.7	2
19.7	4
19.7	6
19.7	8
16.6	10
14.6	12
12.4	14
11	16
10.4	18
9.8	20
8	24
9	28
32	32
36	36
40	40

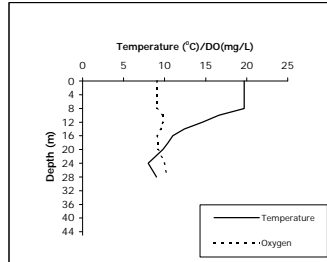


Figure 5g Site 1 July

Temperature	Oxygen
Temp	Depth
21.3	0
21.2	2
21.2	4
21.2	6
21.2	8
21.1	10
21.1	12
21.1	14
21.1	16
21.1	18
21.0	20
20.9	24
20.9	28
20.8	32
19.7	36
18.9	40
14.4	44
13.2	48

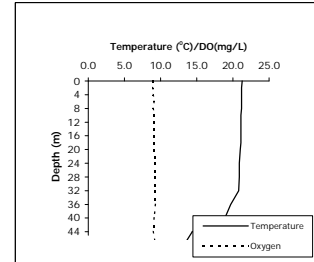


Figure 5j Site 1 August

Temperature	Oxygen
Temp	Depth
19.9	0
19.8	2
19.8	4
19.8	6
18.8	8
16.4	10
12.7	12
11.3	14
10.2	16
9.6	18
9.0	20
8.4	24
7.8	28
32	32
36	36
40	40

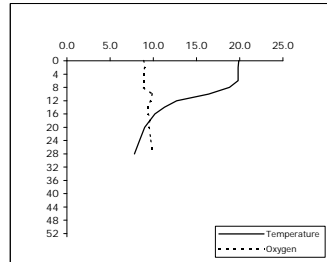


Figure 5h Site 2 July

Temperature	Oxygen
Temp	Depth
21.5	0
21.4	2
21.4	4
21.4	6
21.3	8
21.3	10
21.3	12
21.2	14
21.2	16
21.2	18
21.1	20
21.0	24
10.2	28
32	32
36	36
40	40

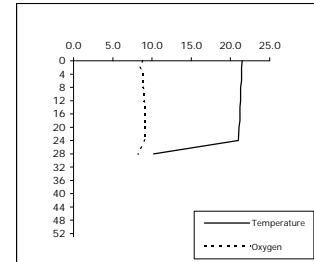


Figure 5k Site 2 August

Temperature	Oxygen
Temp	Depth
20.4	0
20.3	2
20.2	4
20.2	6
19.1	8
17.3	10
13.6	12
11.7	14
10.9	16
9.8	18
9.2	20
8.5	24
8.2	28
32	32
36	36
40	40

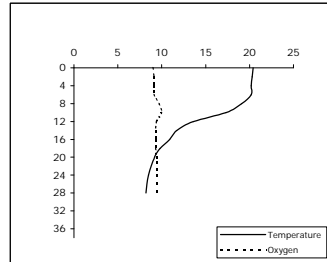


Figure 5i Site 3 July

Temperature	Oxygen
Temp	Depth
22.2	0
22.1	2
22.1	4
22.0	6
21.9	8
21.7	10
21.6	12
21.5	14
21.4	16
21.2	18
21.0	20
18.6	24
8.8	28
32	32
36	36
40	40

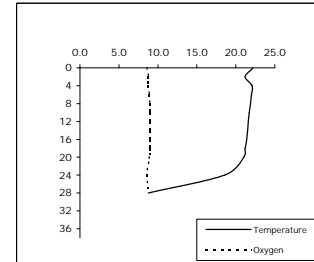


Figure 5l Site 3 August

Figure 5: Temperature/Oxygen Profiles for Skaha Lake for 2001/2002

Temperature	Oxygen
Temp	Depth
18.0	0
18.0	2
18.0	4
18.0	6
18.0	8
18.0	10
18.0	12
17.8	14
17.5	16
15.4	18
13.6	20
11.8	24
10.5	28
	32
	36
	40

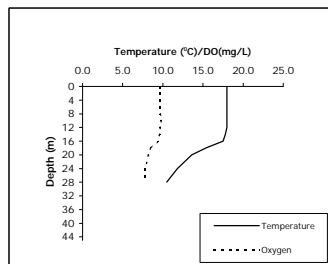


Figure 5m Site 1 September

Temperature	Oxygen
Temp	Depth
10.3	0
10.1	2
10.0	4
10.0	6
10.0	8
10.0	10
9.9	12
9.9	14
9.9	16
9.9	18
9.9	20
9.9	24
9.8	28
	32
	36
	40

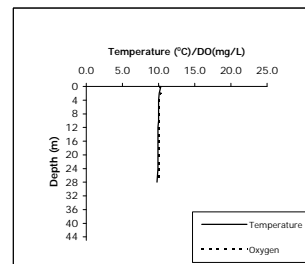


Figure 5p Site 1 October

Temperature	Oxygen
Temp	Depth
17.9	0
17.9	2
18.0	4
18.0	6
18.0	8
18.0	10
18.0	12
18.0	14
18.0	16
18.0	18
18.0	20
18.0	24
17.8	28
	32
	36
	40

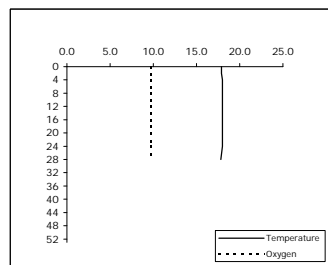


Figure 5n Site 2 September

Temperature	Oxygen
Temp	Depth
9.8	0
9.8	2
9.7	4
9.7	6
9.7	8
9.7	10
9.7	12
9.7	14
9.7	16
9.7	18
9.7	20
9.7	24
9.7	28
	32
	36
	40

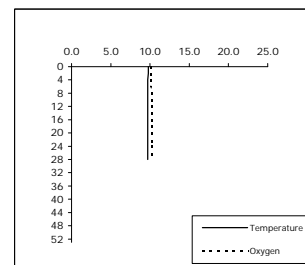


Figure 5q Site 2 October

Temperature	Oxygen
Temp	Depth
17.7	0
17.8	2
17.9	4
18.0	6
18.0	8
18.1	10
18.1	12
18.0	14
18.0	16
16.7	18
12.0	20
10.6	24
9.8	28
9.4	32
	36
	40

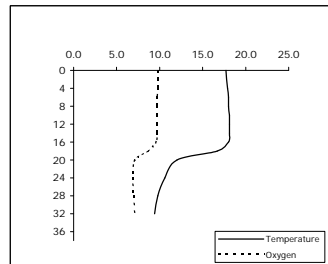


Figure 5o Site 3 September

Temperature	Oxygen
Temp	Depth
9.6	0
9.6	2
9.6	4
9.6	6
9.6	8
9.6	10
9.5	12
9.5	14
9.5	16
9.5	18
9.5	20
9.4	24
9.4	28
	32
	36
	40

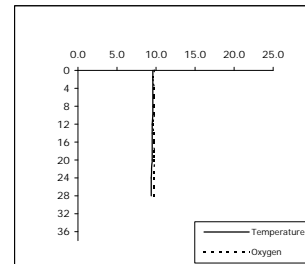


Figure 5r Site 3 October

Figure 5: Temperature/Oxygen Profiles for Skaha Lake for 2001/2002

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
15.5	0	9.6	0
13.7	2	9.7	2
12.8	4	9.8	4
12.4	6	10.0	6
11.8	8	10.0	8
10.2	10	10.2	10
9.3	12	10.1	12
8.8	14	10.1	14
8.6	16	10.2	16
8.2	18	10.2	18
8.0	20	10.3	20
7.3	24	10.3	24
6.9	28	10.5	28
	32		32
	36		36
	40		40

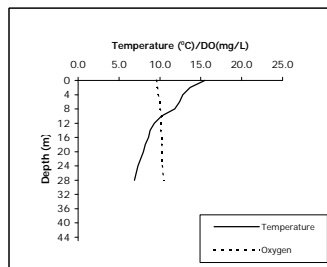


Figure 5s Site 1 November

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
15.5	0	11.3	0
13.6	2	11.6	2
12.9	4	12.0	4
12.3	6	12.3	6
11.8	8	12.4	8
10.4	10	12.3	10
9.6	12	12.3	12
8.6	14	12.3	14
8.0	16	12.4	16
7.6	18	12.5	18
7.8	20	12.2	20
7.0	24	12.3	24
6.6	28	12.1	28
	32		32
	36		36
	40		40

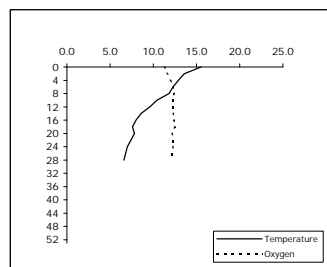


Figure 5t Site 2 November

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
13.0	0	11.9	0
11.8	2	12.2	2
11.2	4	12.3	4
11.0	6	12.4	6
10.5	8	12.4	8
9.2	10	12.3	10
9.0	12	12.4	12
8.8	14	12.4	14
8.4	16	12.3	16
8.2	18	12.3	18
8.0	20	12.5	20
7.6	24	12.2	24
7.2	28	12.7	28
	32		32
	36		36
	40		40

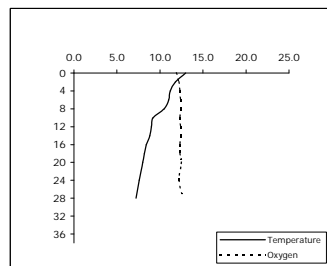


Figure 5u Site 3 November

Figure 5: Temperature/Oxygen Profiles for Skaha Lake, 2001

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
17.5	0	9.2	0
17.2	2	9.5	2
16.9	4	9.5	4
16.8	6	9.5	6
15.8	8	9.0	8
15.0	10	8.8	10
13.3	12	7.9	12
12.5	14	7.3	14
10.8	16	6.4	16
9.8	18	5.8	18
9.1	20	5.0	20
8.8	24	4.4	24
8.5	28	0.4	28
8.5	32	0.2	32
36	36		
40	40		

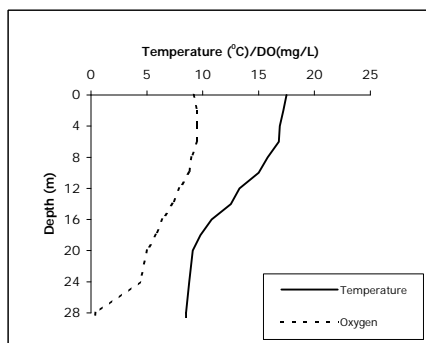


Figure 6a Site 1 May

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
23.0	0	8.6	0
22.0	2	8.6	2
22.7	4	8.5	4
22.6	6	8.0	6
22.5	8	9.0	8
22.3	10	9.0	10
22.2	12	9.0	12
22.2	14	9.1	14
22.1	16	9.1	16
22.1	18	9.1	18
22.0	20	9.0	20
12.0	24	0.2	24
11.2	28	0.1	28
36	36		
40	40		

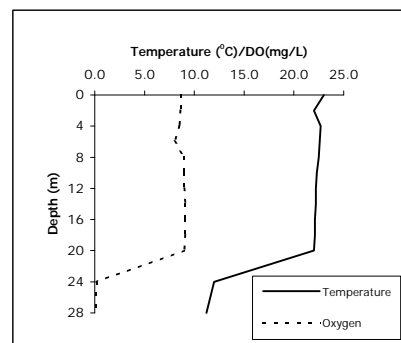


Figure 6d Site 1 August

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
19.8	0	9.5	0
19.2	2	9.8	2
18.5	4	9.9	4
18.0	6	9.9	6
16.7	8	9.0	8
14.6	10	7.3	10
13.1	12	5.5	12
11.6	14	4.8	14
10.8	16	3.9	16
9.8	18	3.3	18
9.6	20	3.0	20
8.8	24	1.0	24
8.7	28	0.1	28
36	36		
40	40		

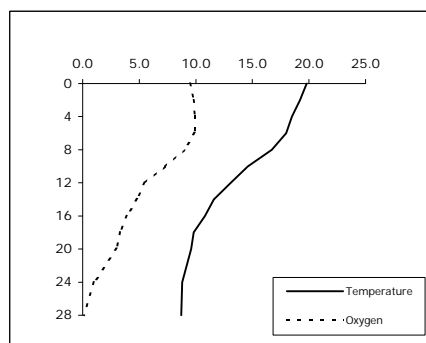


Figure 6b Site 1 June

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
19.4	0	9.4	0
19.2	2	9.6	2
19.1	4	9.7	4
19.0	6	9.7	6
18.9	8	9.7	8
18.8	10	9.8	10
18.7	12	9.8	12
18.5	14	9.4	14
18.3	16	8.8	16
18.0	18	8.7	18
16.6	20	3.0	20
13.3	24	0.2	24
36	36		
40	40		

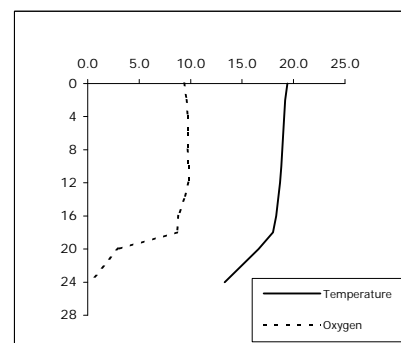


Figure 6e Site 1 September

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
21.9	0	8.5	0
21.2	2	8.5	2
20.8	4	8.3	4
20.6	6	8.1	6
19.7	8	6.7	8
17.9	10	5.1	10
15.3	12	2.9	12
15.7	14	1.2	14
12.3	16	0.8	16
10.8	18	0.3	18
10.2	20	0.2	20
9.5	24	0.1	24
9.4	28	0.0	28
36	36		
40	40		

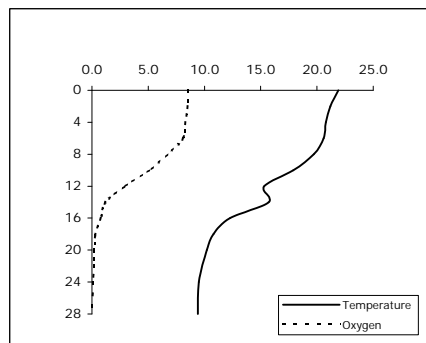


Figure 6c Site 1 July

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
9.0	0	10.7	0
9.0	2	10.7	2
9.0	4	10.7	4
9.0	6	10.7	6
9.0	8	10.6	8
9.0	10	10.6	10
9.0	12	10.6	12
9.0	14	10.6	14
9.0	16	10.6	16
9.0	18	10.7	18
8.9	20	10.7	20
36	36		
40	40		

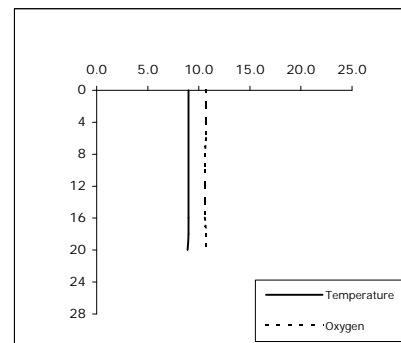


Figure 6f Site 1 October

Temperature	Oxygen	Temperature	Oxygen
Temp	Depth	Temp	Depth
6.9	0	11.6	0
6.9	2	11.6	2
6.9	4	11.2	4
6.9	6	11.0	6
6.9	8	11.1	8
6.9	10	11.0	10
6.9	12	11.2	12
6.9	14	11.3	14
6.9	16	11.5	16
6.9	18	11.5	18
6.9	20	11.5	20
6.9	24	11.6	24
6.9	28	11.6	28
36	36		
40	40		

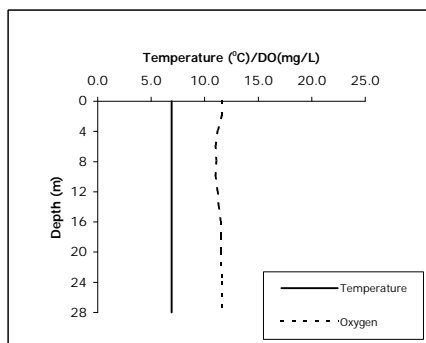


Figure 6g Site 1 November

Figure 6: Temperature/Oxygen Profiles for Vaseux Lake, 2001

Temperature	Oxygen	
Temp	Depth	Oxygen Depth
20.9	0	5.1 0
17.8	2	5.7 2
16.0	4	6.4 4
14.7	6	6.7 6
14.0	8	7.0 8
12.6	10	7.2 10
12.0	12	7.5 12
10.9	14	7.6 14
10.2	16	8.2 16
9.2	18	15.2 18
7.9	20	17.4 20
7.7	24	14.3 24
7.5	28	14.3 28
	32	32
	36	36
	40	40

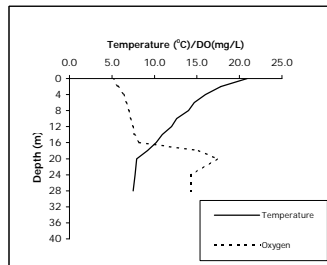


Figure 7a Site 1 May

Temperature	Oxygen	
Temp	Depth	Oxygen Depth
18.3	0	9.2 0
17.2	2	9.8 2
16.7	4	10.2 4
16.5	6	10.4 6
16.4	8	10.5 8
16.1	10	10.5 10
15.9	12	10.4 12
14.9	14	10.4 14
12.1	16	9.8 16
10.9	18	9.2 18
10.0	20	8.9 20
8.9	24	9.1 24
8.5	28	9.2 28
	32	32
	36	36
	40	40

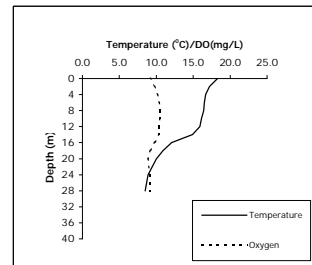


Figure 7e Site 1 June

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
18.2	0	7.2	0
17.1	2	7.3	2
16.5	4	7.8	4
16.7	6	7.9	6
16.2	8	8.1	8
15.9	10	8.3	10
14.7	12	8.3	12
12.2	14	8.4	14
10.8	16	8.5	16
10.9	18	8.5	18
8.7	20	8.8	20
7.9	24	9.3	24
	28		28
	32		32
	36		36
	40		40

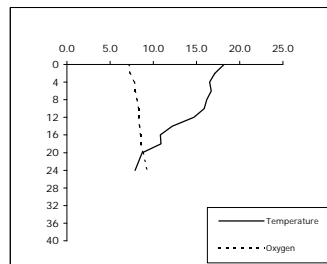


Figure 7b Site 2 May

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
17.1	0	10.2	0
17.0	2	10.2	2
16.8	4	10.3	4
16.8	6	10.4	6
16.8	8	10.4	8
16.8	10	10.3	10
16.7	12	10.3	12
15.8	14	10.0	14
13.8	16	9.2	16
12.1	18	8.9	18
11.3	20	8.9	20
9.3	24	8.9	24
8.9	28	9.0	28
	32		32
	36		36
	40		40

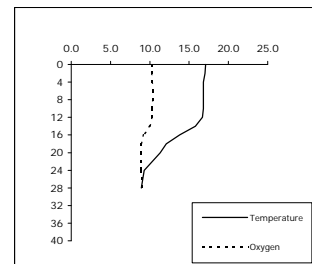


Figure 7f Site 2 June

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
20.2	0	6.3	0
18.6	2	6.6	2
16.2	4	7.2	4
15.1	6	8.2	6
14.2	8	8.8	8
11.8	10	9.0	10
10.3	12	9.0	12
9.5	14	8.5	14
9.2	16	8.2	16
8.8	18	7.9	18
8.6	20	8.1	20
8.2	24	8.3	24
8.0	28	8.5	28
	32		32
	36		36
	40		40

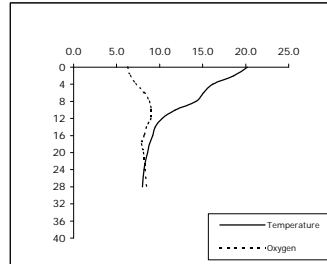


Figure 7c Site 3 May

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
20.0	0	8.9	0
19.2	2	9.8	2
18.7	4	10.1	4
18.6	6	10.5	6
16.4	8	10.1	8
14.0	10	9.1	10
10.8	12	5.7	12
9.9	14	4.3	14
9.7	16	3.8	16
9.2	18	3.2	18
8.9	20	2.6	20
8.7	24	1.3	24
8.7	28	0.1	28
	32		32
	36		36
	40		40

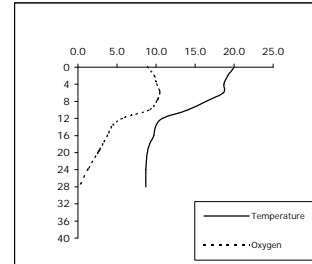


Figure 7g Site 3 June

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
20.6	0	4.1	0
18.2	2	4.8	2
17.8	4	5.2	4
17.1	6	5.5	6
15.2	8	6.6	8
13.7	10	8.1	10
13.0	12	8.8	12
12.4	14	7.2	14
11.7	16	10.0	16
11.4	18	11.2	18
11.2	20	11.5	20
10.7	24	7.3	24
	28		28
	32		32
	36		36
	40		40

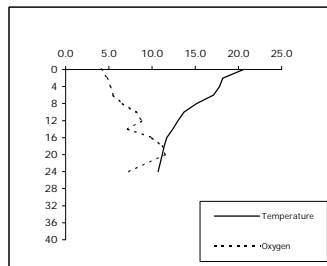


Figure 7d Site 4 May

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
20.5	0	9.1	0
18.9	2	9.5	2
18.4	4	9.8	4
18.2	6	9.9	6
17.9	8	9.9	8
17.5	10	9.7	10
17.0	12	8.8	12
14.9	14	2.6	14
13.9	16	1.2	16
13.5	18	0.8	18
13.2	20	0.7	20
12.2	24	0.2	24
12.3	28	0.0	28
	32		32
	36		36
	40		40

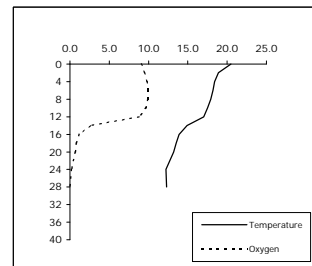


Figure 7h Site 4 June

Figure 7: Temperature/Oxygen Profiles for Osoyoos Lake, 2001

Temperature	Oxygen
Temp	Depth Oxygen Depth
20.0	0 9.3 0
20.0	2 9.2 2
20.0	4 9.1 4
20.0	6 9.0 6
20.0	8 9.0 8
20.0	10 8.8 10
19.3	12 8.4 12
17.2	14 7.7 14
15.8	16 7.4 16
13.9	18 6.8 18
11.1	20 6.9 20
9.3	24 7.2 24
8.9	28 7.1 28
	32 32
	36 36
	40 40

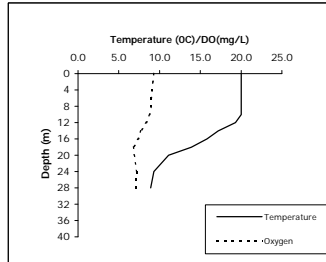


Figure 7i Site 1 July

Temperature	Oxygen
Temp	Depth Oxygen Depth
21.9	0 8.8 0
21.8	2 8.9 2
21.8	4 9.0 4
21.6	6 9.2 6
21.4	8 9.3 8
21.3	10 9.2 10
21.0	12 9.0 12
20.2	14 8.8 14
20.4	16 8.4 16
20.0	18 8.0 18
19.2	20 7.2 20
14.4	24 4.8 24
11.6	28 4.9 28
10.1	32 5.4 32
	36 36
	40 40

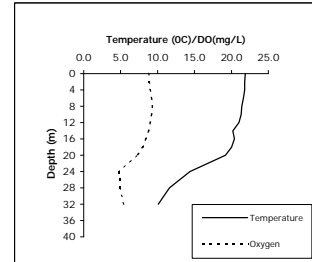


Figure 7m Site 1 August

Temperature	Oxygen
Temp	Depth Oxygen Depth
20.0	0 9.1 0
20.2	2 9.0 2
20.2	4 9.0 4
20.3	6 8.9 6
20.3	8 8.9 8
20.3	10 8.8 10
20.3	12 8.8 12
20.3	14 8.8 14
18.7	16 7.9 16
17.4	18 7.7 18
15.4	20 7.2 20
14.2	24 7.0 24
10.5	28 6.5 28
9.4	32 6.9 32
	36 36
	40 40

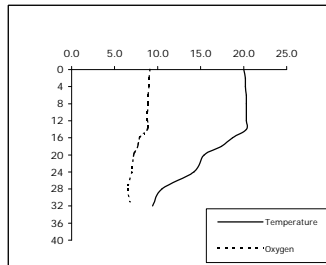


Figure 7j Site 2 July

Temperature	Oxygen
Temp	Depth Oxygen Depth
22.2	0 9.2 0
22.2	2 9.2 2
22.1	4 9.2 4
22.1	6 9.2 6
21.9	8 9.2 8
21.8	10 9.2 10
21.5	12 9.0 12
13.7	14 4.8 14
12.5	16 4.8 16
18.4	18 4.8 18
16.0	20 6.2 20
11.1	24 5.1 24
9.9	28 5.3 28
11.2	32 6.1 32
	36 36
	40 40

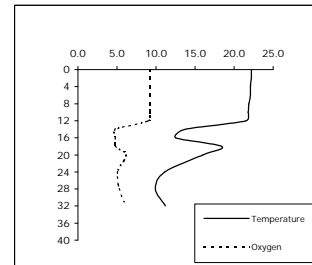


Figure 7n Site 2 August

Temperature	Oxygen
Temp	Depth Oxygen Depth
20.9	0 8.8 0
20.8	2 8.8 2
20.7	4 8.8 4
20.6	6 8.7 6
20.0	8 8.4 8
15.7	10 6.7 10
12.3	12 3.1 12
11.3	14 1.0 14
10.4	16 0.5 16
10.1	18 0.3 18
9.7	20 0.2 20
9.3	24 0.1 24
9.0	28 0.1 28
	32 32
	36 36
	40 40

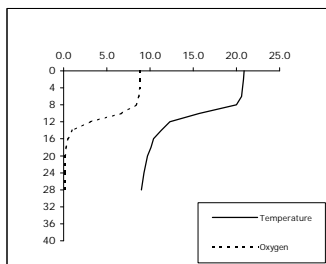


Figure 7k Site 3 July

Temperature	Oxygen
Temp	Depth Oxygen Depth
23.8	0 8.9 0
23.5	2 9.1 2
23.3	4 9.2 4
22.4	6 9.3 6
21.4	8 9.0 8
20.7	10 8.1 10
14.7	12 0.7 12
12.5	14 0.2 14
11.4	16 0.1 16
10.8	18 0.1 18
10.1	20 0.1 20
9.6	24 0.0 24
9.3	28 0.1 28
	32 32
	36 36
	40 40

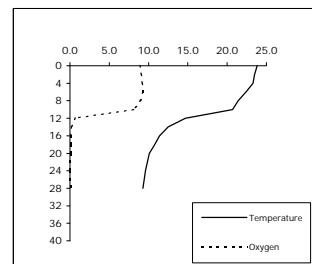


Figure 7o Site 3 August

Temperature	Oxygen
Temp	Depth Oxygen Depth
21.5	0 8.8 0
21.4	2 8.9 2
21.2	4 8.9 4
21.1	6 9.0 6
21.0	8 9.0 8
21.0	10 8.9 10
18.0	12 3.1 12
16.6	14 0.7 14
15.6	16 0.1 16
15.0	18 0.1 18
14.6	20 0.1 20
13.8	24 0.1 24
13.1	28 0.0 28
	32 32
	36 36
	40 40

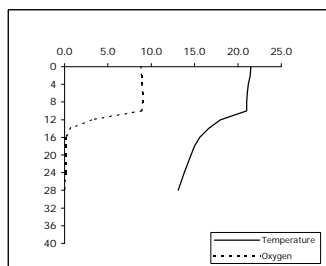


Figure 7l Site 4 July

Temperature	Oxygen
Temp	Depth Oxygen Depth
24.3	0 9.1 0
24.0	2 9.3 2
23.4	4 9.5 4
22.4	6 9.4 6
21.7	8 8.2 8
21.2	10 7.0 10
20.7	12 5.7 12
18.1	14 0.2 14
16.8	16 0.1 16
16.2	18 0.1 18
15.9	20 0.1 20
15.4	24 0.0 24
14.5	28 0.0 28
	32 32
	36 36
	40 40

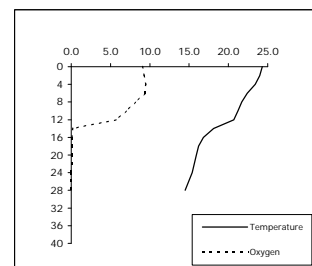


Figure 7p Site 4 August

Figure 7: Temperature/Oxygen Profiles for Osoyoos Lake, 2001

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
20.8	0	8.9	0
19.4	2	9.4	2
18.8	4	9.8	4
18.4	6	9.8	6
18.2	8	9.8	8
18.1	10	9.8	10
18.0	12	9.9	12
17.9	14	9.9	14
14.9	16	5.0	16
11.0	18	3.4	18
10.0	20	3.6	20
9.5	24	3.6	24
9.1	28	3.3	28
	32		32
	36		36
	40		40

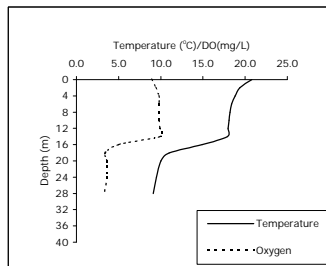


Figure 7q Site 1 September

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
10.3	0	9.6	0
10.3	2	9.6	2
10.3	4	9.6	4
10.3	6	9.6	6
10.3	8	9.6	8
10.3	10	9.6	10
10.3	12	9.6	12
10.3	14	9.6	14
10.3	16	9.7	16
10.3	18	9.7	18
10.3	20	9.6	20
10.3	24	9.7	24
10.3	28	9.7	28
	32		32
	36		36
	40		40

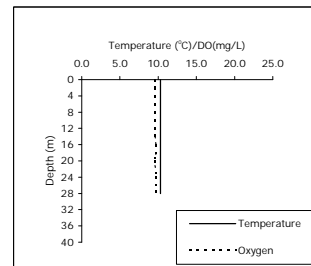


Figure 7u Site 1 October

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
19.0	0	10.0	0
18.6	2	9.8	2
18.3	4	9.9	4
18.2	6	9.7	6
18.0	8	9.6	8
17.9	10	9.6	10
17.7	12	9.3	12
17.5	14	8.9	14
13.9	16	4.2	16
10.3	18	3.4	18
9.7	20	3.4	20
9.2	24	3.3	24
8.8	28	3.3	28
	32		32
	36		36
	40		40

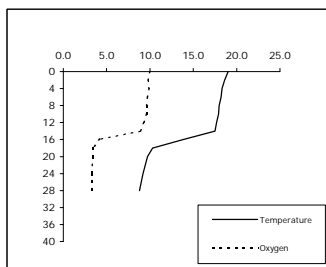


Figure 7r Site 2 September

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
10.1	0	9.5	0
10.2	2	9.5	2
10.2	4	9.5	4
10.2	6	9.5	6
10.2	8	9.5	8
10.2	10	9.5	10
10.2	12	9.5	12
10.3	14	9.5	14
10.3	16	9.5	16
10.3	18	9.5	18
10.3	20	9.5	20
10.2	24	9.5	24
10.2	28	9.5	28
	32		32
	36		36
	40		40

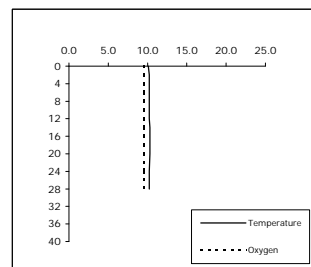


Figure 7v Site 2 October

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
21.3	0	10.3	0
20.0	2	10.3	2
19.4	4	10.4	4
19.0	6	10.4	6
18.5	8	9.9	8
18.2	10	9.4	10
17.9	12	8.6	12
17.4	14	7.5	14
15.7	16	2.7	16
12.4	18	0.1	18
11.2	20	0.1	20
10.5	24	0.0	24
10.6	28	0.0	28
	32		32
	36		36
	40		40

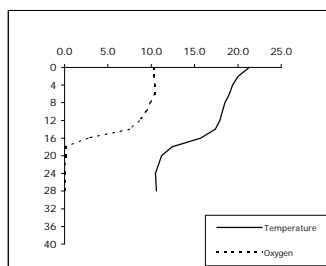


Figure 7s Site 3 September

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
9.6	0	10.1	0
9.8	2	9.7	2
9.8	4	9.6	4
9.9	6	9.6	6
9.9	8	9.6	8
10.0	10	9.6	10
10.0	12	9.6	12
10.0	14	9.6	14
10.0	16	9.6	16
10.0	18	9.6	18
10.0	20	9.6	20
10.0	24	9.6	24
9.6	28	9.7	28
	32		32
	36		36
	40		40

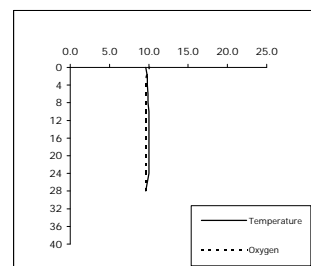


Figure 7w Site 3 October

Temperature		Oxygen	
Temp	Depth	Oxygen	Depth
21.2	0	10.5	0
20.4	2	10.6	2
20.0	4	10.8	4
19.6	6	10.6	6
19.4	8	10.0	8
19.2	10	9.0	10
19.1	12	8.6	12
19.0	14	8.6	14
18.9	16	8.3	16
18.8	18	8.2	18
18.6	20	9.0	20
18.0	24	3.8	24
	28		28
	32		32
	36		36
	40		40

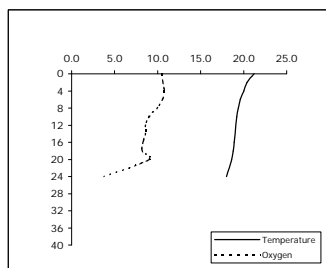


Figure 7t Site 4 September

Temperature	Oxygen		
Temp	Depth	Oxygen	Depth
10.7	0	9.8	0
10.8	2	9.8	2
10.9	4	9.8	4
10.9	6	9.8	6
10.9	8	9.8	8
10.9	10	9.9	10
10.9	12	9.8	12
10.9	14	9.8	14
10.9	16	9.8	16
10.9	18	9.8	18
10.9	20	9.8	20
10.9	24	9.9	24
	28		28
	32		32
	36		36
	40		40

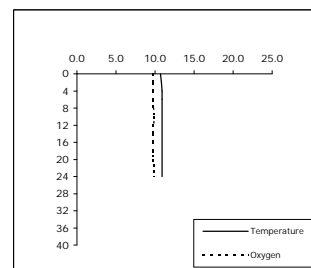


Figure 7x Site 4 October

Figure 7: Temperature/Oxygen Profiles for Osoyoos Lake, 2001

Temperature	Oxygen
Temp	Depth Oxygen Depth
8.8	0 9.8 0
8.8	2 9.8 2
8.8	4 9.8 4
8.8	6 9.8 6
8.8	8 9.8 8
8.8	10 9.4 10
8.8	12 9.4 12
8.8	14 9.8 14
8.8	16 9.9 16
8.8	18 9.9 18
8.8	20 9.7 20
8.8	24 9.4 24
8.8	28 9.7 28
	32 32
	36 36
	40 40

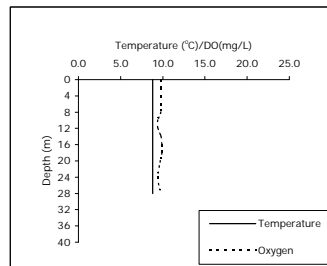


Figure 7y Site 1 November

Temperature	Oxygen
Temp	Depth Oxygen Depth
7.3	0 9.7 0
7.6	2 9.6 2
7.7	4 9.3 4
7.8	6 9.5 6
7.8	8 9.6 8
7.9	10 9.6 10
7.9	12 9.6 12
8.0	14 9.6 14
8.0	16 9.5 16
8.0	18 9.4 18
8.0	20 9.1 20
8.0	24 9.5 24
8.0	28 9.6 28
8.8	32 9.8 32
	36 36
	40 40

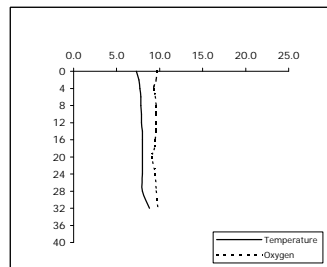


Figure 7z Site 2 November

Temperature	Oxygen
Temp	Depth Oxygen Depth
6.6	0 12.4 0
6.8	2 13.8 2
7.1	4 11.3 4
7.1	6 10.6 6
7.1	8 10.4 8
7.1	10 10.6 10
7.2	12 10.6 12
7.2	14 10.3 14
7.2	16 10.7 16
7.2	18 10.7 18
7.2	20 10.7 20
7.2	24 10.7 24
7.2	28 10.7 28
	32 32
	36 36
	40 40

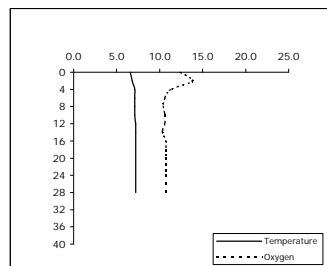


Figure 7aa Site 3 November

Temperature	Oxygen
Temp	Depth Oxygen Depth
6.4	0 13.1 0
6.7	2 11.9 2
6.9	4 12.8 4
7.1	6 13.3 6
7.1	8 14.2 8
7.2	10 13.1 10
7.3	12 12.1 12
7.3	14 13.1 14
7.3	16 11.5 16
7.4	18 12.6 18
7.4	20 12.0 20
7.4	24 12.0 24
7.4	28 15.1 28
	32 32
	36 36
	40 40

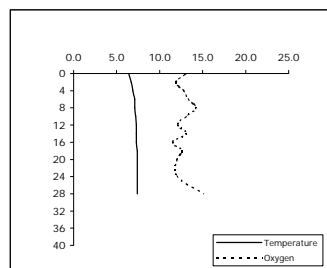


Figure 7bb Site 4 November

Figure 7: Temperature/Oxygen Profiles for Osoyoos Lake, 2001

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A		A	
M	0	M	45
J	0	J	45
J	10	J	45
A	42	A	45
S	16	S	45
O	0	O	45
N		N	
D		D	

*max depth, assume $\geq 4\text{mg/L}$

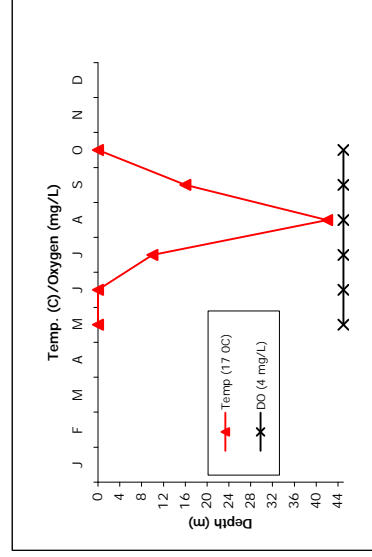


Figure 8a Skaha Lake Site 1 River Mouth

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A		A	
M	0	M	53
J	0	J	53
J	10	J	53
A	28	A	53
S	32	S	53
O	0	O	53
N		N	
D		D	

*max depth, assume $\geq 4\text{mg/L}$

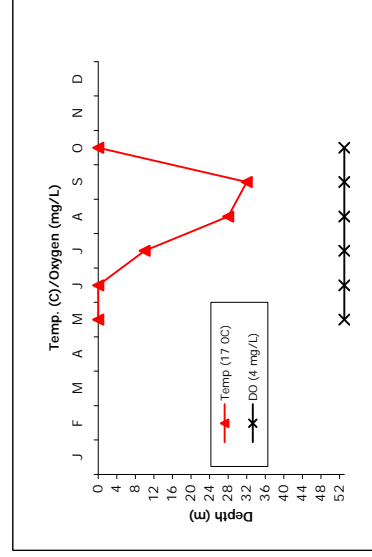


Figure 8b Skaha Lake Site 2 Gillies

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A		A	
M	0	M	37
J	8	J	37
J	12	J	37
A	28	A	37
S	18	S	37
O	0	O	37
N		N	
D		D	

*max depth, assume $\geq 4\text{mg/L}$

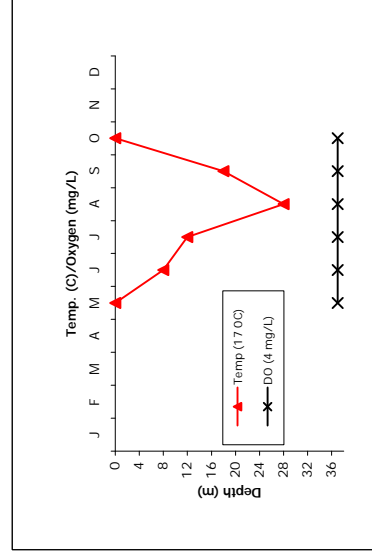


Figure 8c Skaha Lake Site 3 South Basin

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A		A	
M	4	M	24
J	8	J	16
J	12	J	12
A	24	A	24
S	20	S	20
O	0	O	20
N		N	
D		D	

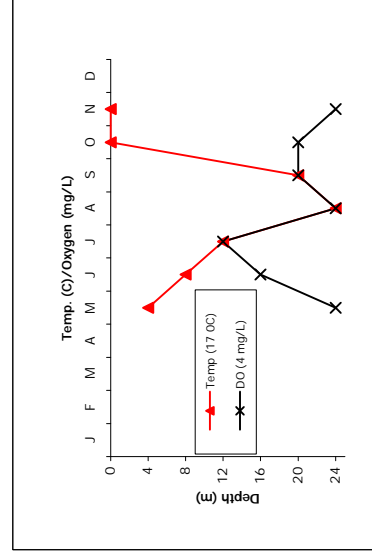


Figure 8d Vaseaux Lake Site 1 Deep Center

Figure 8: Zones of Tolerance for *Oncorhynchus nerka* in Skaha, Vaseaux, and Osoyoos Lakes, 2001

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A	4	A	37
M		M	*
J	4	J	37
J	14	J	37
A	24	A	32
S	16	S	18
O	0	O	37
N	0	N	*
D		D	37

*max depth, assume ≥ 4mg/L

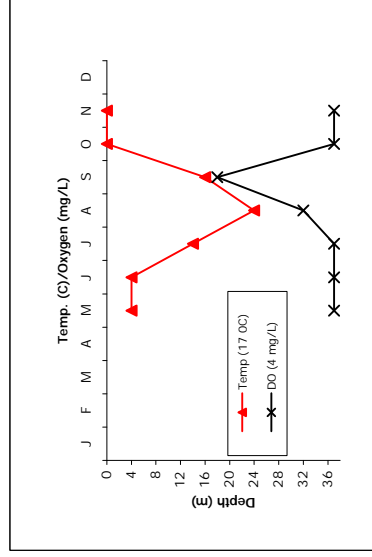


Figure 8e Osoyoos Lake Site 1 North Basin

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A	2	A	60
M		M	*
J	4	J	60
J	18	J	60
A	14	A	60
S	16	S	18
O	0	O	60
N	0	N	*
D		D	60

*max depth, assume ≥ 4mg/L

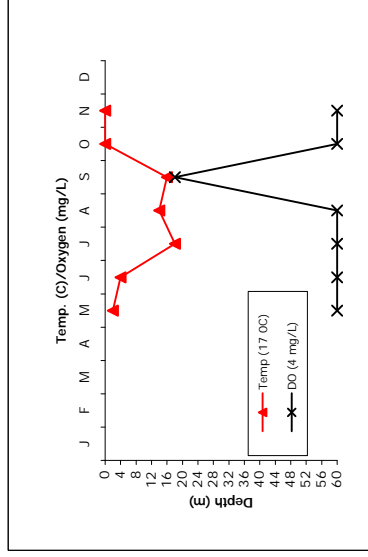


Figure 8f Osoyoos Lake Site 2 Monashee Co-op

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A	4	A	30
M		M	*
J	8	J	16
J	10	J	12
A	12	A	12
S	16	S	16
O	0	O	30
N	0	N	*
D		D	30

*max depth, assume ≥ 4mg/L

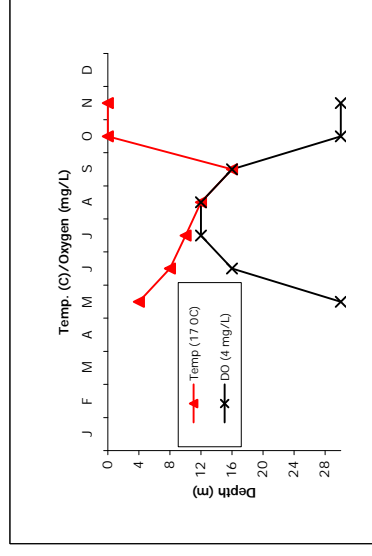


Figure 8g Osoyoos Lake Site 3 Central Basin

Temp (17 °C)	DO (4 mg/L)	Month	Depth (m)
J		J	
F		F	
M		M	
A	8	A	24
M		M	14
J	12	J	12
J	14	J	14
A	16	A	22
S	24	S	24
O	0	O	24
N	0	N	24
D		D	24

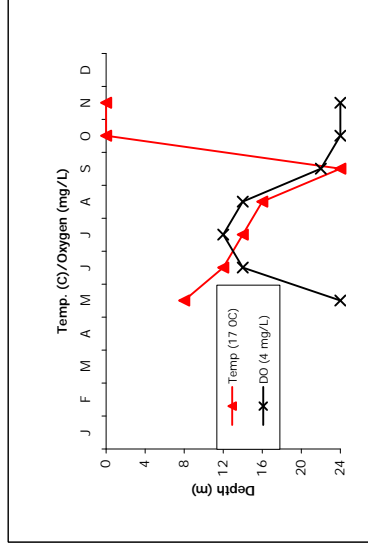


Figure 8h Osoyoos Lake Site 4 South Basin

Figure 8: Zones of Tolerance for *Oncorhynchus nerka* in Skaha, Vaseaux, and Osoyoos Lakes, 2001

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F	0.22	0.22	0.19 *
	M			
	A			
	M	0.21	0.24	0.21
	J	0.28	0.18	0.20
	J	0.24	0.25	0.24
	A	0.26	0.22	0.42
	S	0.12	0.22	0.22
	O			
	N			
	D			
	Average	0.22	0.22	0.25

* indicates prov. Data pooled

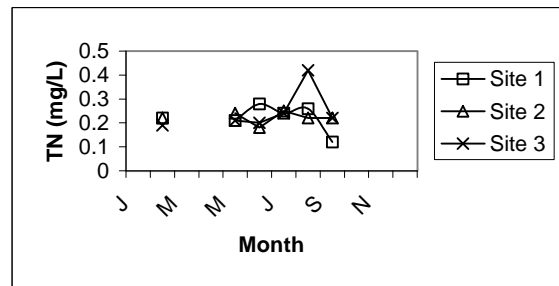


Figure 9a: Total Nitrogen Levels at 0 to 10m for Skaha Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F	0.22	0.21	0.22
	M			
	A			
	M	0.20	0.25	0.23
	J	0.13	0.14	0.16
	J	0.25	0.19	0.22
	A	0.20	0.22	0.23
	S	0.22	0.22	0.22 *
	O			
	N			
	D			
	Average	0.20	0.21	0.21

* indicates prov. Data pooled

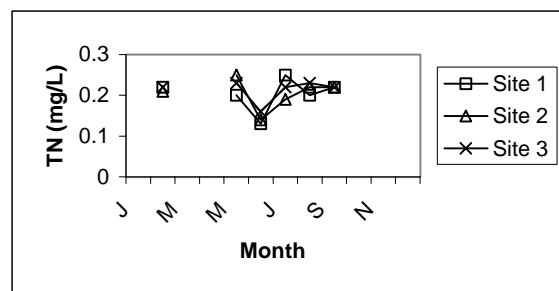


Figure 9b: Total Nitrogen Levels at 20m for Skaha Lake

Year	Depth	36m	45m	36m
2001	Month	Site 1	Site 2	Site 3
	J			
	F*	0.21	0.21	0.22
	M			
	A			
	M	0.20	0.22	0.21
	J	0.15	0.16	0.17
	J	0.21	0.26	0.25
	A	0.17	0.20	0.24
	S	0.22	0.22	0.25 *
	O			
	N			
	D			
	Average	0.19	0.21	0.22

* indicates prov. Data pooled

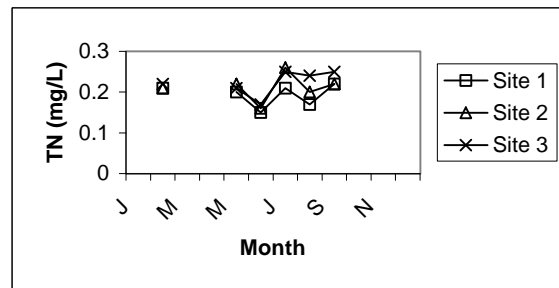


Figure 9c: Total Nitrogen Levels at Deep Sections for Skaha Lake

Year	Month	0-10m	15m	>18m
2001	J			
	F			
	M			
	A			
	M	0.21	0.24	0.23
	J	0.20	0.37	0.50
	J	0.24	0.52	0.54
	A	0.25	0.44	0.76
	S	0.24	0.42	0.71
	O			
	N			
	D			
	Average	0.23	0.40	0.55

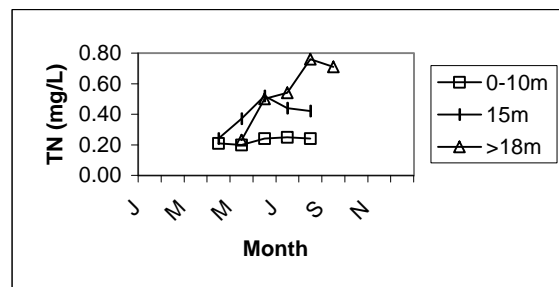


Figure 9d: Total Nitrogen Levels for Vaseux Lake

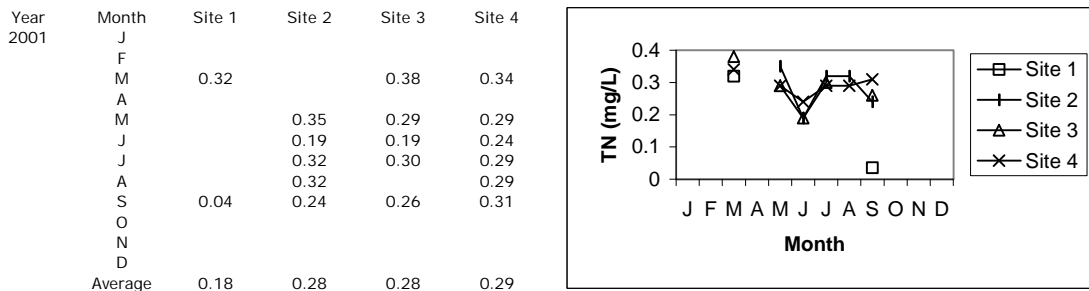


Figure 9e: Total Nitrogen Levels at 0 - 10 m for Osoyoos Lake

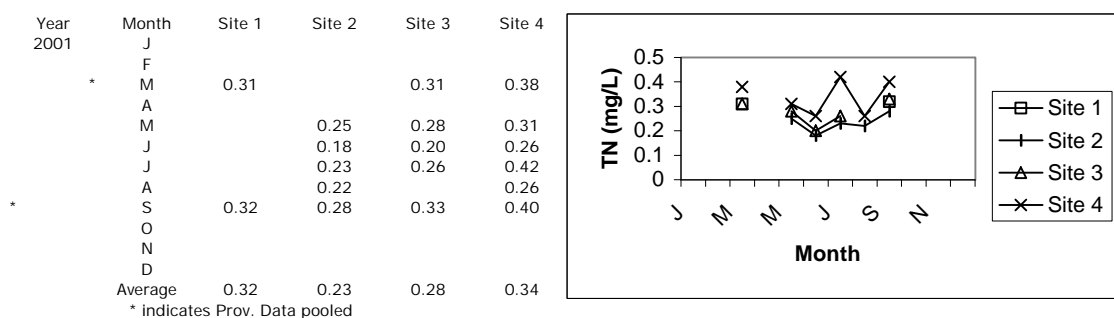


Figure 9f: Total Nitrogen Levels at 20 m for Osoyoos Lake

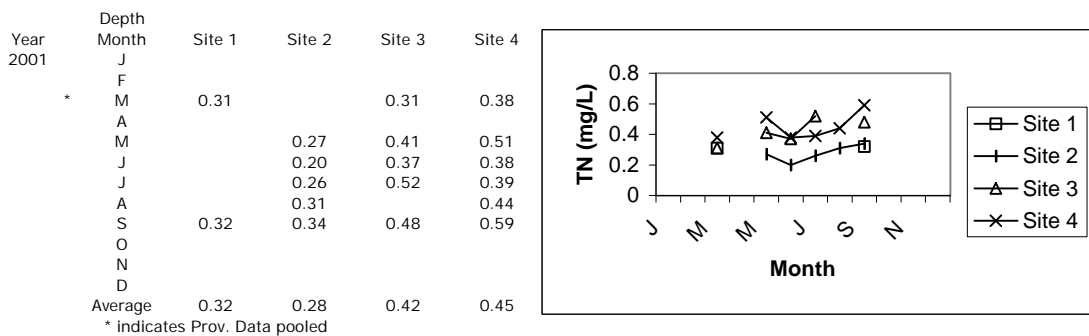


Figure 9g: Total Nitrogen Levels at Deep Sections for Osoyoos Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F	0.002	0.007	0.002
	M			
	A			
	M	0.002	0.002	0.002
	J	0.002	0.002	0.002
	J	0.003	0.002	0.002
	A	0.002	0.002	0.002
	S	0.002	0.002	0.002
	O			
	N			
	D			
	Average	0.002	0.003	0.002

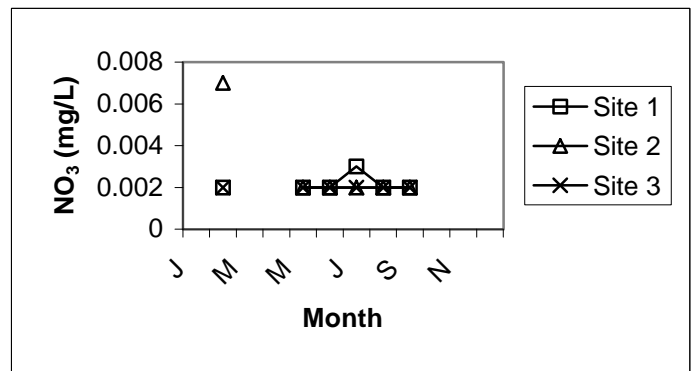


Figure 10a: Nitrate-Nitrogen levels at 0-10m for Skaha Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F*	0.002	0.007	0.002
	M			
	A			
	M	0.002	0.002	0.002
	J	0.003	0.002	0.01
	J	0.002	0.005	0.011
	A	0.002	0.002	0.002
	S	0.002	0.002	0.002
	O			
	N			
	D			
	Average	0.002	0.003	0.005

* indicates Prov. Data pooled

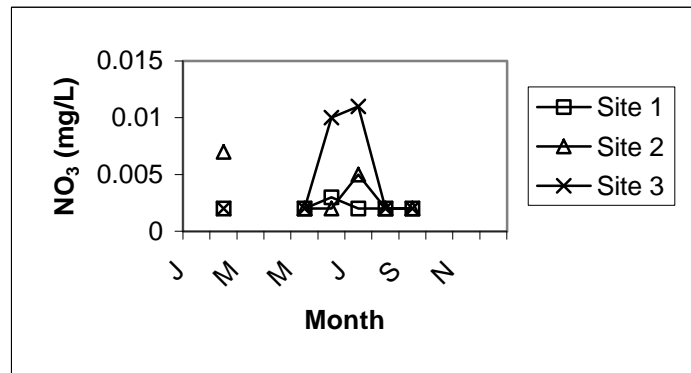


Figure 10b: Nitrate-Nitrogen Levels at 20m for Skaha Lake

Year	Depth	36m	45m	36m
Month	Site 1	Site 2	Site 3	
2001	J			
	F*	0.002	0.007	0.002
	M			
	A			
	M	0.002	0.004	0.003
	J	0.015	0.012	0.015
	J	0.027	0.064	0.042
	A	0.011	0.031	0.042
	S	0.025	0.046	0.058
	O			
	N			
	D			
	Average	0.014	0.027	0.027

* indicates Prov. Data pooled

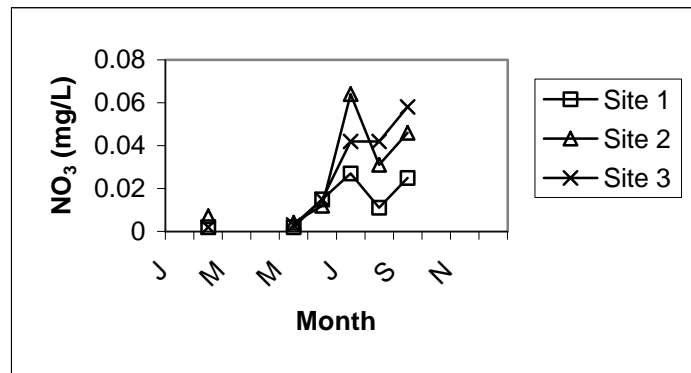


Figure 10c: Nitrate-Nitrogen Levels at Deep Sections for Skaha Lake

Year	Month	0-10m	15m	>18m
2001	J			
	F			
	M			
	A			
	M	0.002	0.007	0.008
	J	0.002	0.221	0.267
	J	0.002	0.291	0.294
	A	0.002	0.181	0.175
	S	0.002	0.054	0.017
	O			
	N			
	D			
	Average	0.002	0.151	0.152

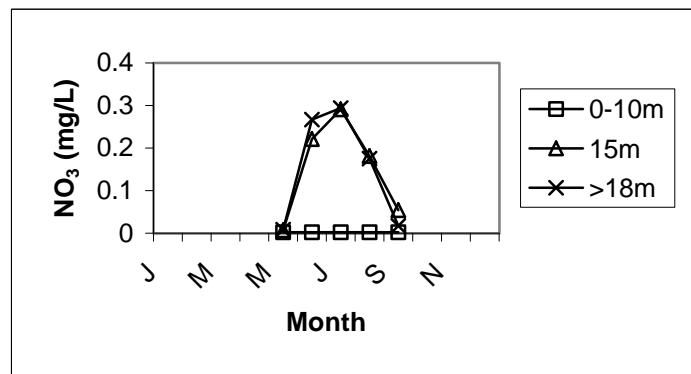


Figure 10d: Nitrate-Nitrogen Levels for Vaseux Lake

Year	Month	Site 1	Site 2	Site 3	Site 4
2001	J				
	F				
	M	0.035		0.01	0.04
	A				
	M		0.002	0.002	0.002
	J		0.002	0.002	0.002
	J		0.002	0.002	0.002
	A		0.002		0.002
	S	0.011	0.002	0.002	0.002
	O				
	N				
	D				
	Average	0.023	0.002	0.004	0.008

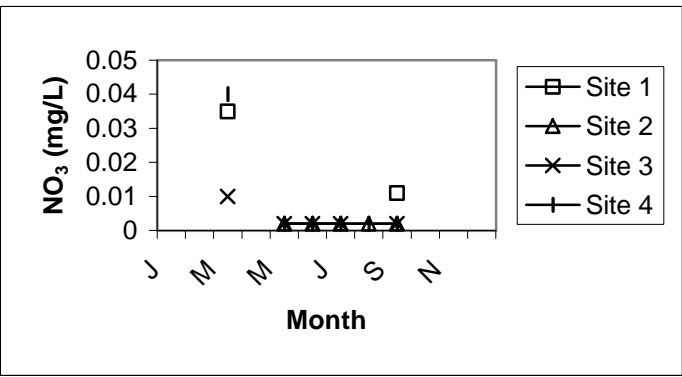


Figure 10e: Nitrate-Nitrogen Levels at 0 - 10 m for Osoyoos Lake

Year	Month	Site 1*	Site 2	Site 3	Site 4
2001	J				
	F				
	M*	0.048		0.014	0.051
	A				
	M		0.007	0.002	0.016
	J		0.014	0.008	0.012
	J		0.024	0.003	0.006
	A		0.015		0.002
	S	0.152	0.092	0.002	0.008
	O				
	N				
	D				
	Average	0.100	0.030	0.006	0.016

* indicates Prov. Data pooled

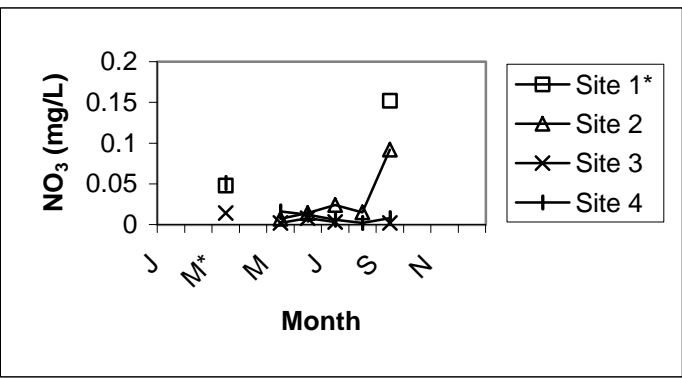


Figure 10f: Nitrate-Nitrogen Levels at 20 m for Osoyoos Lake

Year	Depth	Month	Site 1*	Site 2	Site 3	Site 4
2001	J					
	F					
	M		0.048		0.014	0.051
	A					
	M			0.014	0.004	0.024
	J			0.066	0.008	0.011
	J			0.069	0.002	0.005
	A			0.108		0.002
	S		0.152	0.167	0.002	0.002
	O					
	N					
	D					
	Average		0.100	0.085	0.006	0.016

* indicates Prov. Data pooled

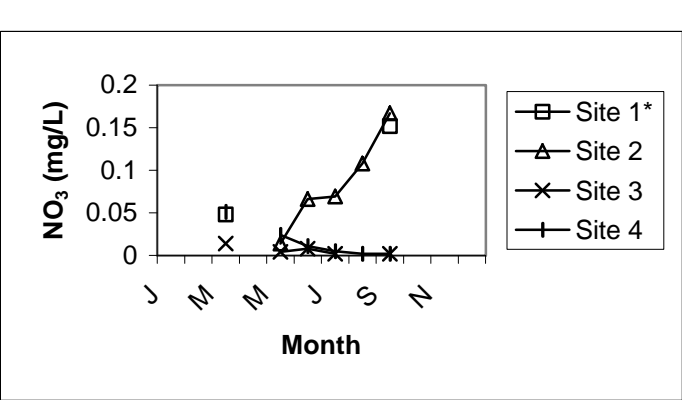


Figure 10g: Nitrate-Nitrogen Levels at Deep Sections for Osoyoos Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F	0.014	0.011	0.012
	M			
	A			
	M	0.009	0.009	0.003
	J	0.011	0.010	0.012
	J	0.010	0.009	0.012
	A	0.016	0.008	0.008
	S	0.007	0.010	0.019
	O			
	N			
	D			
	Average	0.011	0.010	0.011

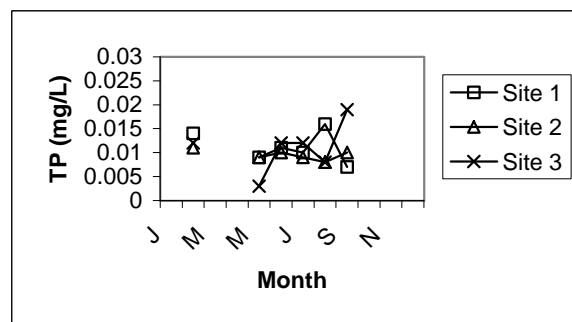


Figure 11a: Total Phosphorous Levels at 0 to 10m for Skaha Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F*	0.012	0.007	0.013
	M			
	A			
	M	0.009	0.008	0.030
	J	0.007	0.008	0.010
	J	0.010	0.009	0.011
	A	0.009	0.014	0.011
	S	0.008	0.009	0.015
	O			
	N			
	D			
	Average	0.009	0.009	0.015

* indicates Prov. Data pooled

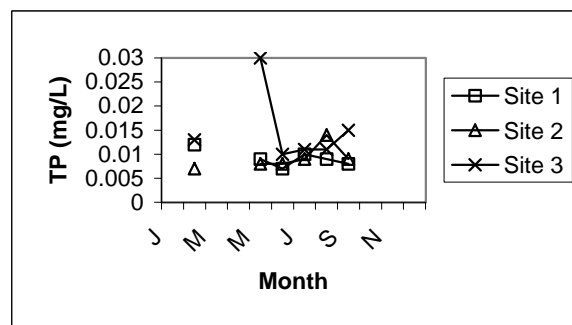


Figure 11b: Total Phosphorous Levels at 20m for Skaha Lake

Year	Depth	36m	45m	36m
	Month	Site 1	Site 2	Site 3
2001	J			
	F*	0.012	0.007	0.013
	M			
	A			
	M	0.007	0.009	0.004
	J	0.009	0.010	0.011
	J	0.006	0.016	0.017
	A	0.007	0.010	0.013
	S	0.007	0.011	0.020
	O			
	N			
	D			
	Average	0.008	0.011	0.013

* indicates Prov. Data pooled

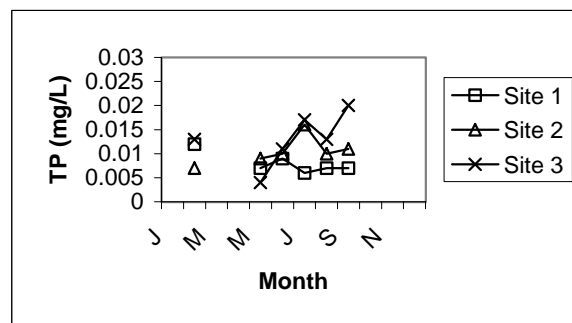


Figure 11c: Total Phosphorous Levels at Deep Sections for Skaha Lake

Year	Month	0-10m	15m	>18m
2001	J			
	F			
	M			
	A			
	M	0.015	0.020	0.019
	J	0.011	0.066	0.019
	J	0.018	0.110	0.140
	A	0.015	0.138	0.290
	S	0.016	0.148	0.280
	O			
	N			
	D			
	Average	0.015	0.096	0.150

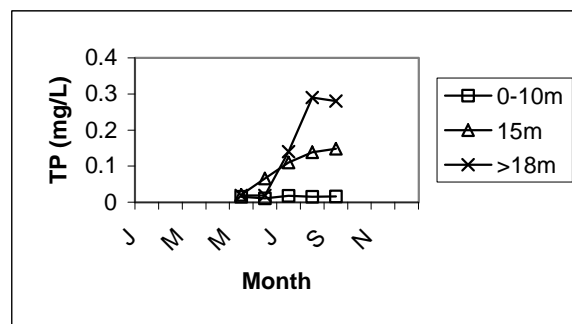


Figure 11d: Total Phosphorous Levels for Vaseux Lake

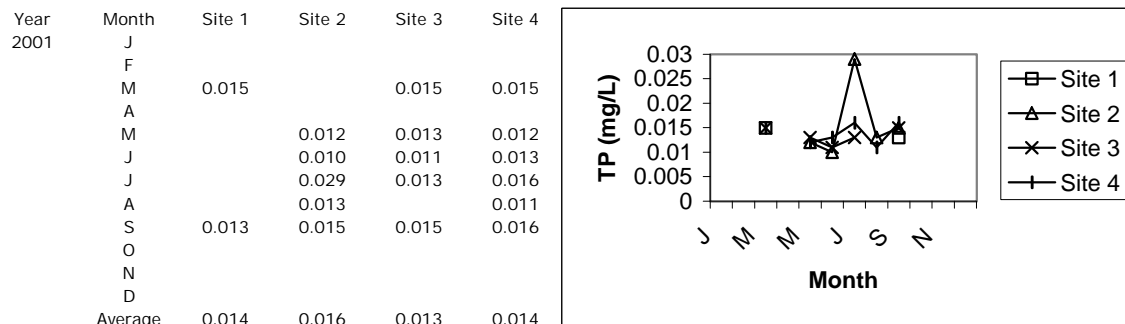


Figure 11e: Total Phosphorous Levels at 0 - 10 m for Osoyoos Lake

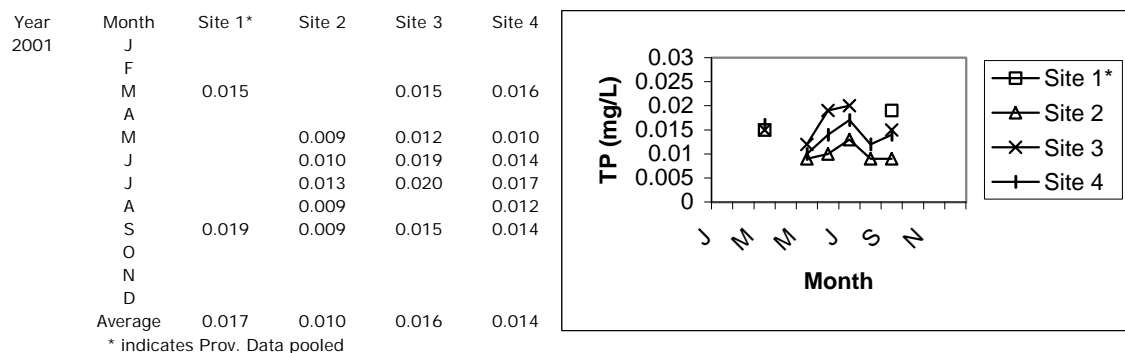


Figure 11f: Total Phosphorous Levels at 20 m for Osoyoos Lake

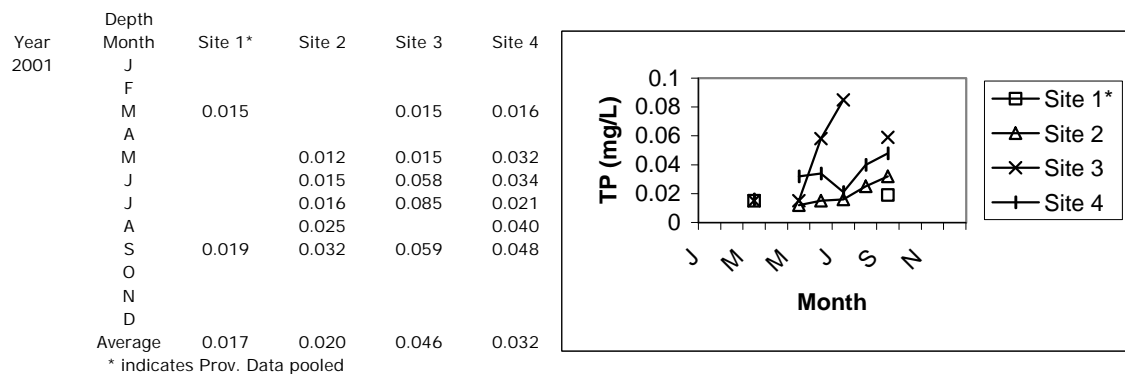


Figure 11g: Total Phosphorous Levels at Deep Sections for Osoyoos Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F	0.007	0.006	0.007
	M			
	A			
	M	0.004	0.004	0.003
	J	0.003	0.003	0.003
	J	0.004	0.004	0.008
	A	0.012	0.004	0.003
	S	0.004	0.006	0.014
	O			
	N			
	D			
	Average	0.0054	0.0042	0.0062

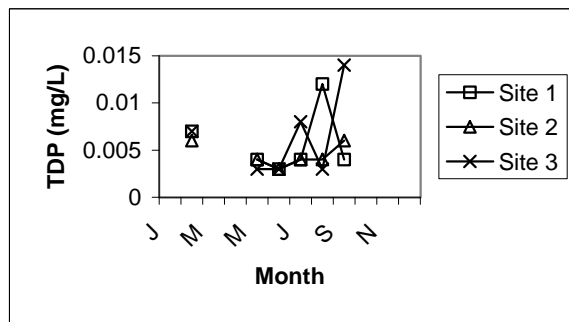


Figure 12a: Total Dissolved Phosphorous Levels at 0 to 10m for Skaha Lake

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F*	0.007	0.007	0.003
	M			
	A			
	M	0.003	0.004	0.003
	J	0.003	0.003	0.004
	J	0.004	0.004	0.005
	A	0.004	0.003	0.004
	S	0.003	0.004	0.005
	O			
	N			
	D			
	Average	0.0034	0.0036	0.0042

* indicates Prov. Data pooled

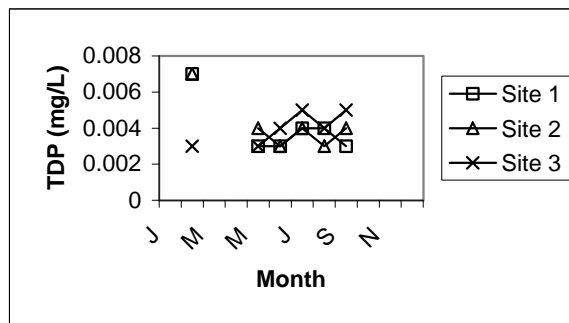


Figure 12b: Total Dissolved Phosphorous Levels at 20m for Skaha Lake

Year	Depth	36m	45m	36m
Month	Site 1	Site 2	Site 3	
2001	J			
	F*	0.007	0.007	0.003
	M			
	A			
	M	0.003	0.006	0.004
	J	0.006	0.004	0.006
	J	0.003	0.011	0.010
	A	0.003	0.006	0.008
	S	0.004	0.008	0.012
	O			
	N			
	D			
	Average	0.0038	0.007	0.008

* indicates Prov. Data pooled

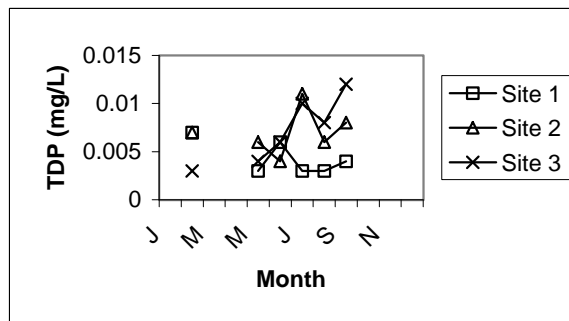


Figure 12c: Total Dissolved Phosphorous Levels at Deep Sections for Skaha Lake

Year	Month	0-10m	15m	>18m
2001	J			
	F			
	M			
	A			
	M	0.004	0.007	0.008
	J	0.004	0.055	0.102
	J	0.008	0.098	0.120
	A	0.008	0.119	0.123
	S	0.006	0.121	0.227
	O			
	N			
	D			
	Average	0.006	0.08	0.116

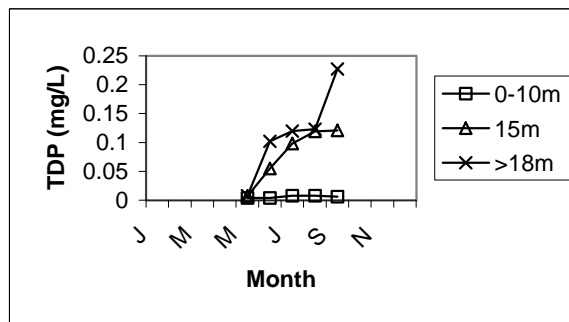


Figure 12d: Total Dissolved Phosphorous Levels for Vaseux Lake

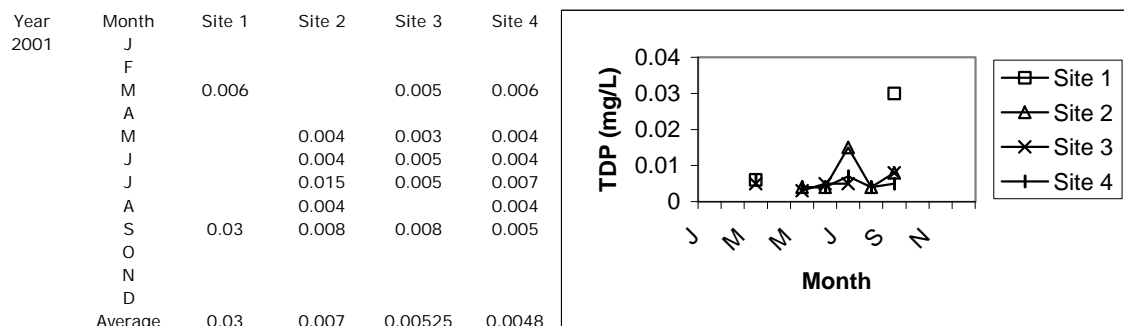


Figure 12e: Total Dissolved Phosphorous Levels at 0 - 10 m for Osoyoos Lake

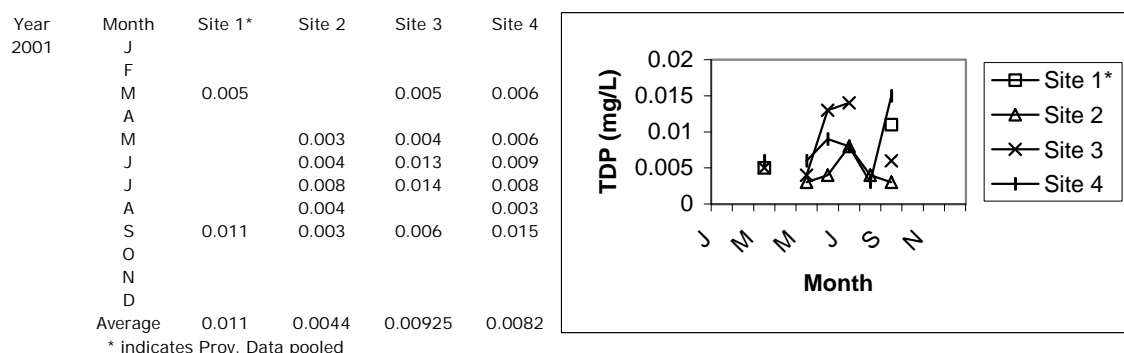


Figure 12f: Total Dissolved Phosphorous Levels at 20 m for Osoyoos Lake

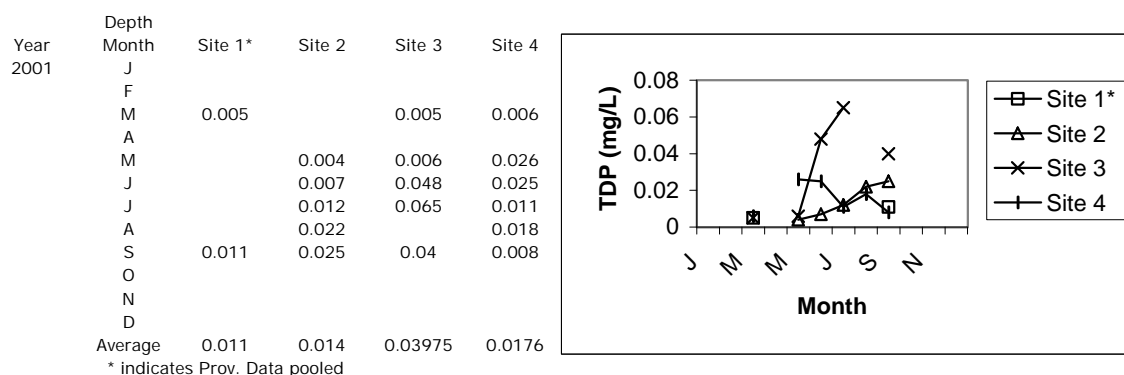


Figure 12g: Total Dissolved Phosphorous Levels at Deep Sections for Osoyoos Lake

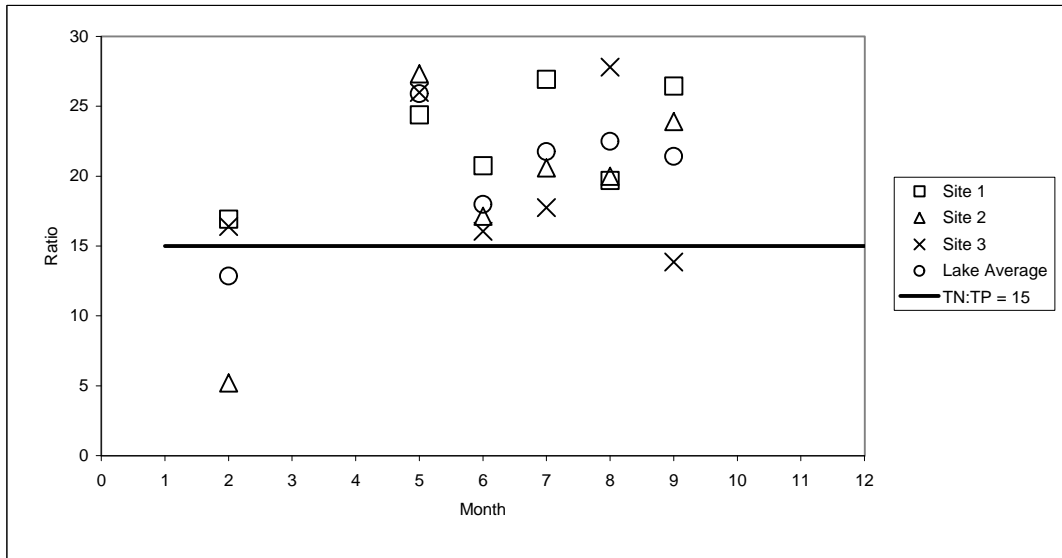


Figure 13a: Total Nitrogen:Total Phosphorous Ratio for Skaha Lake 2001

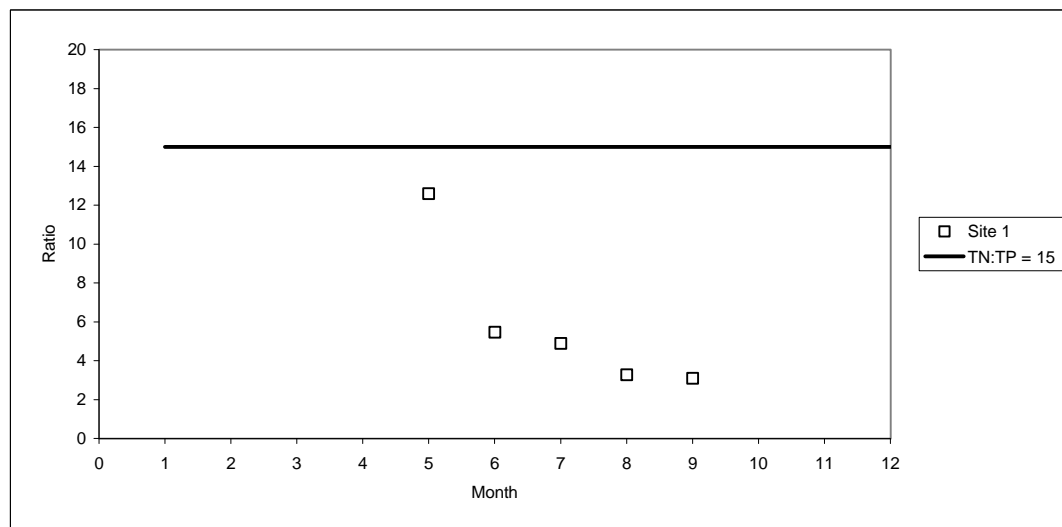


Figure 13b: Total Nitrogen:Total Phosphorous Ratio for Vaseux Lake, 2001

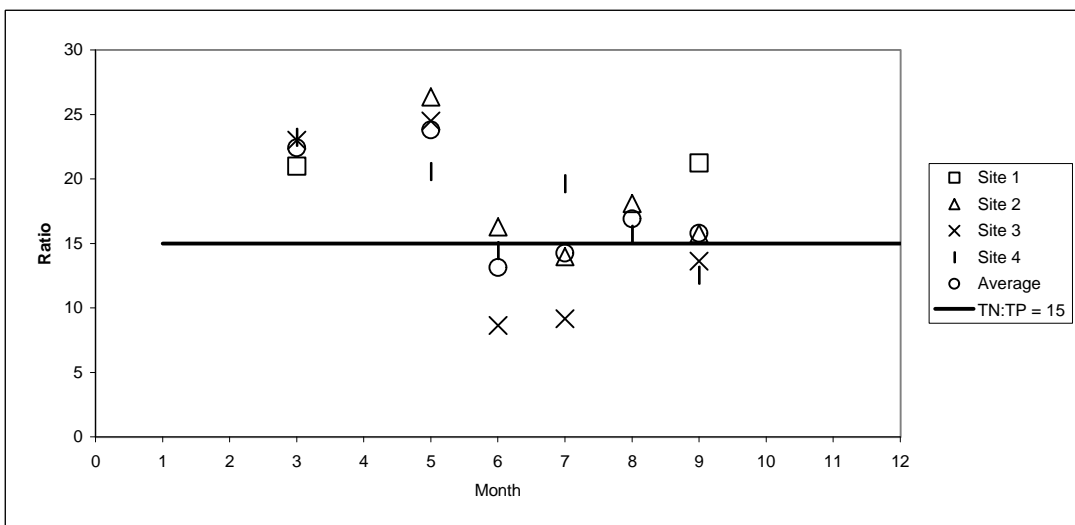


Figure 13c: Total Nitrogen:Total Phosphorous Ratio for Osoyoos Lake, 2001

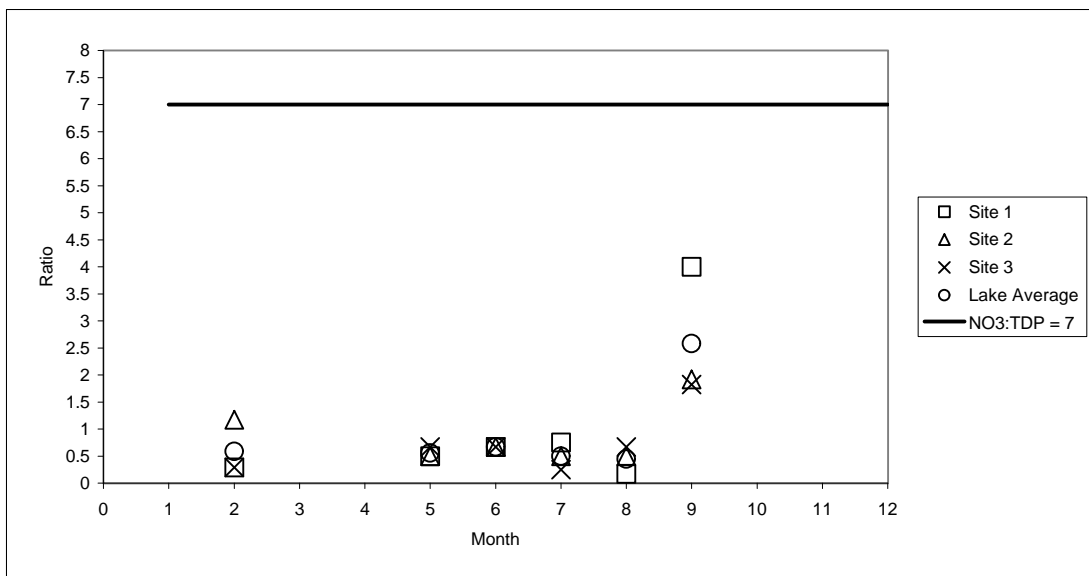


Figure 14a: N03/TDP ratio at 0 to 10m for Skaha Lake 2001

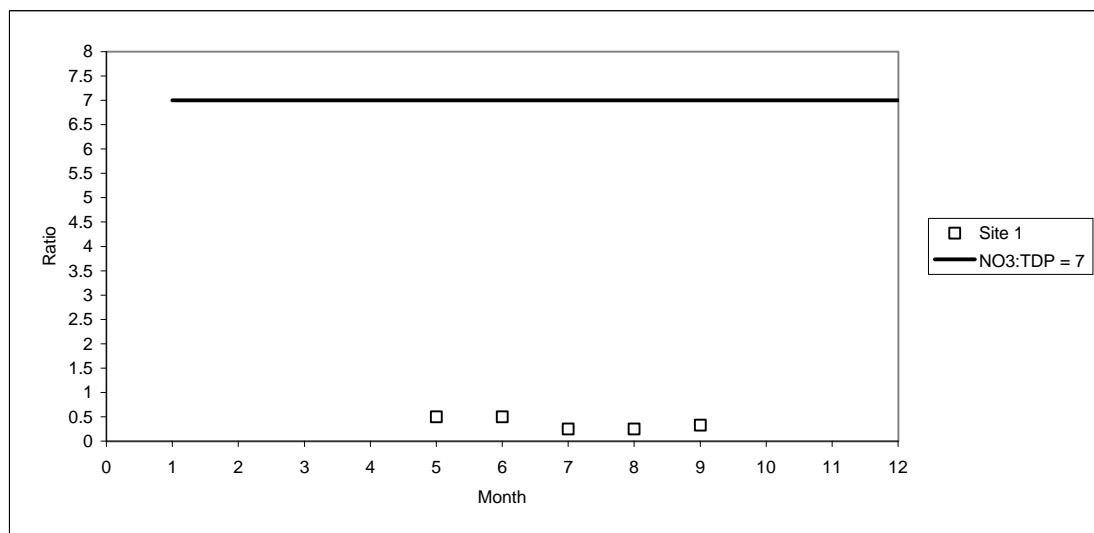


Figure 14b: N03/TDP ratio at 0 to 10m for Vaseux Lake, 2001

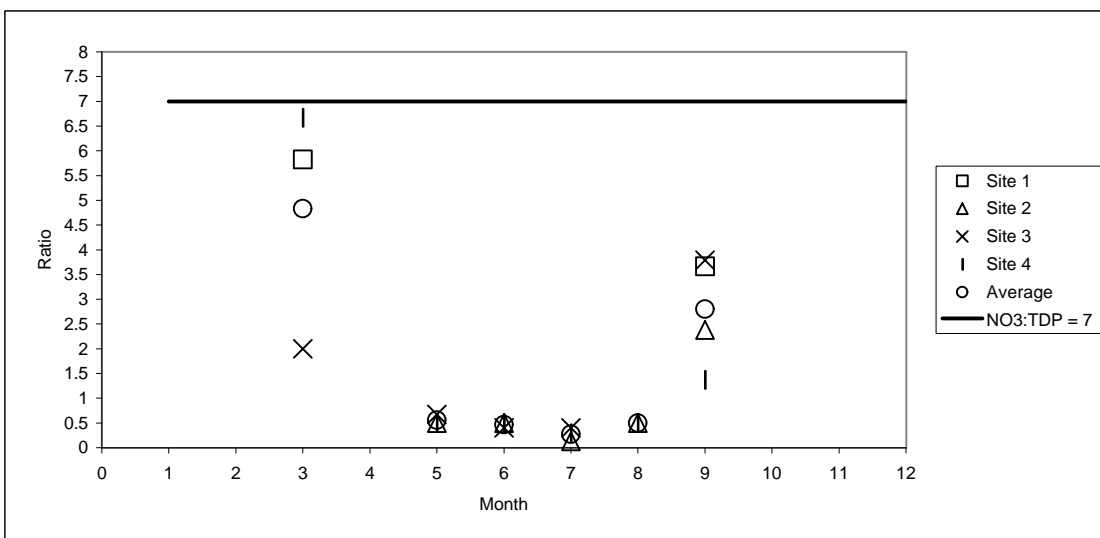


Figure 14c: N03/TDP ratio at 0 to 10m for Osoyoos Lake, 2001

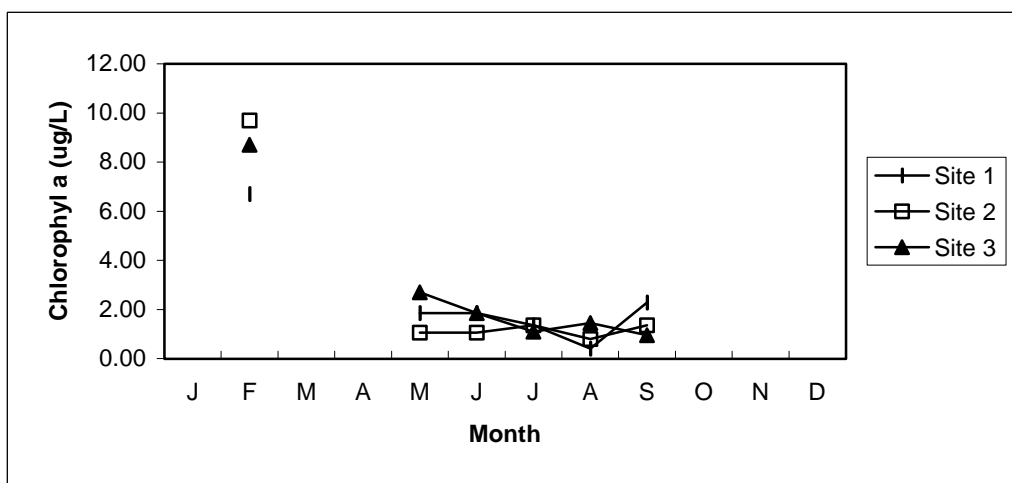


Figure 15a: Chlorophyll a levels at 0-10m for Skaha Lake, 2001

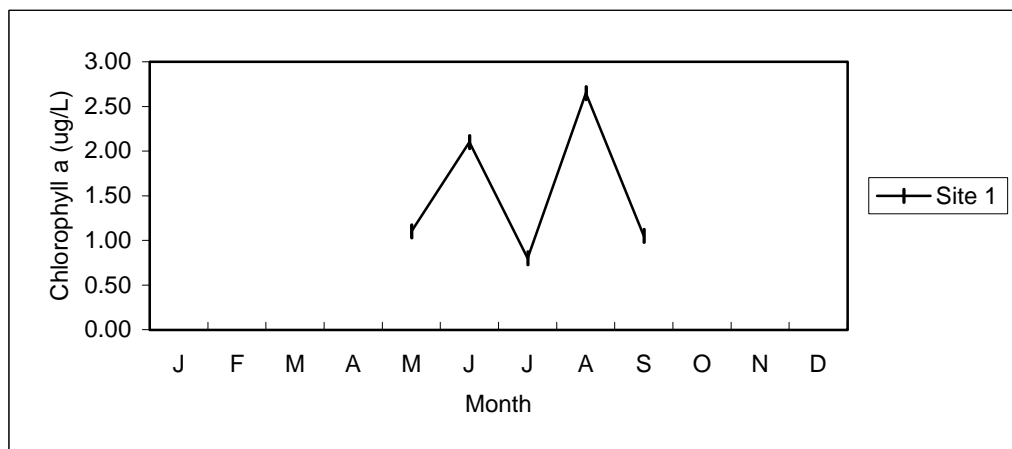


Figure 15b: Chlorophyll a levels at 0-10m for Vaseux Lake, 2001

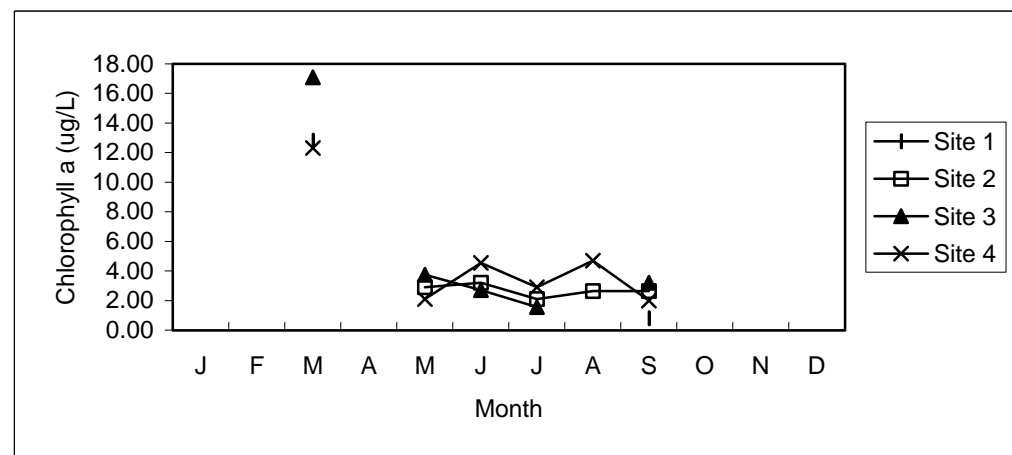


Figure 15c: Chlorophyll a levels at 0-10m for Osoyoos Lake, 2001

Year	Month	Site 1	Site 2	Site 3
2001	J			
	F		5.1	
	M			
	A			
	M			4.7
	J	4.4	0.4	4.2
	J	5.1	4.8	4.9
	A	5.4	5.4	5.4
	S	5.8	5.8	5.9
	O			
	N			
	D			

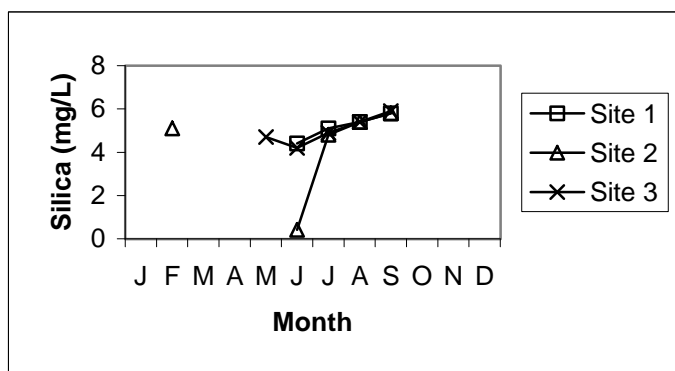
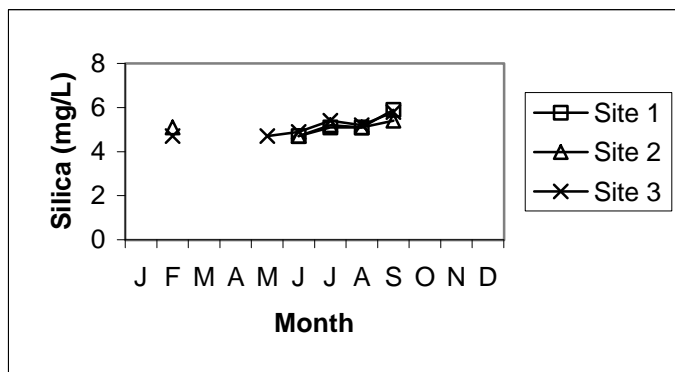


Figure 16a: Silica Levels at 0 to 10m for Skaha Lake, 2001

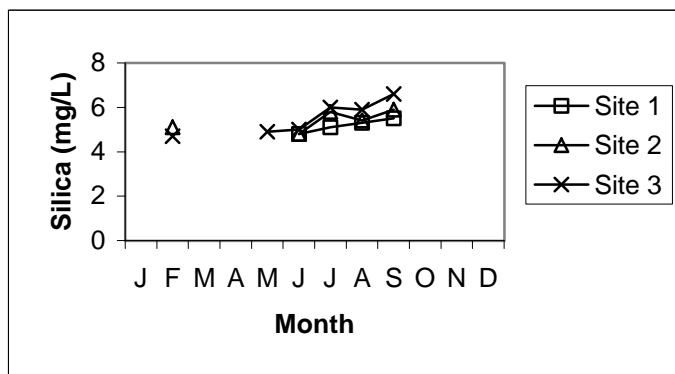
Year	Month	Site 1	Site 2	Site 3
2001	J			
	F*		5.1	4.7
	M			
	A			
	M			4.7
	J	4.7	4.7	4.9
	J	5.1	5.2	5.4
	A	5.1	5.1	5.2
	S	5.9	5.4	5.8
	O			
	N			
	D			



* indicates Prov. Data pooled

Figure 16b: Silica Levels at 20m for Skaha Lake, 2001

Year	Depth	36m	45m	36m
Month	Site 1	Site 2	Site 3	
2001	J			
	F*		5.1	4.7
	M			
	A			
	M			4.9
	J	4.8	4.8	5.0
	J	5.1	5.8	6.0
	A	5.3	5.4	5.9
	S	5.5	5.9	6.6
	O			
	N			
	D			



* indicates Prov. Data pooled

Figure 16c: Silica Levels at Deep Sections for Skaha Lake, 2001

Year	Month	0-10m	15m	>18m
2001	J			
	F			
	M			
	A			
	M	5.4	6.3	6.3
	J	5.0	7.7	8.1
	J	5.6	9.8	9.7
	A	5.6	10.5	10.6
	S	6.2	9.9	10.4
	O			
	N			
	D			

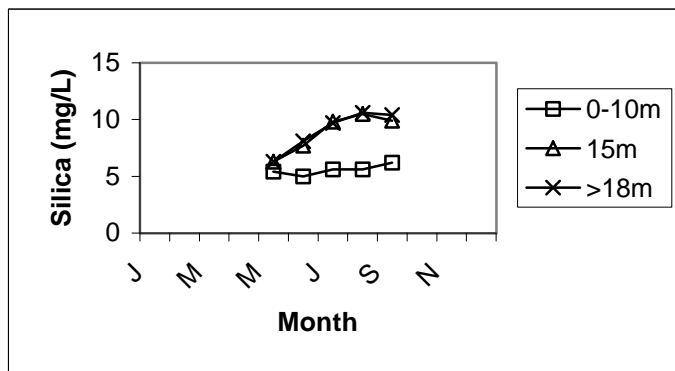


Figure 16d: Silica Levels for Vaseux Lake, 2001

Year	Month	Site 1	Site 2	Site 3	Site 4
2001	J				
	F				
	M				
	A				
	M		3.3	2.8	4.3
	J		2.0	2.2	3.9
	J		3.3	3.3	4.4
	A		4.6		
	S		5.2	4.9	6.7
	O				
	N				
	D				

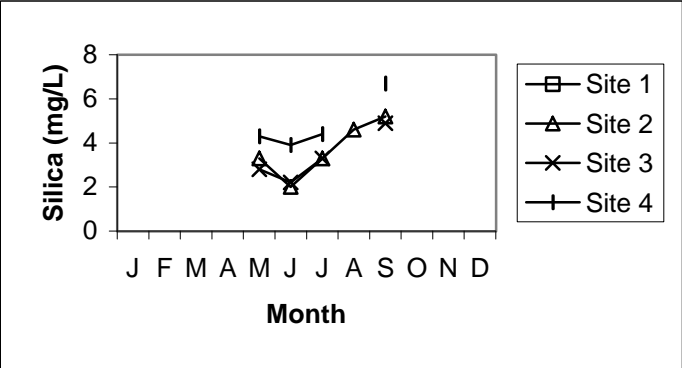


Figure 16e: Silica Levels at 0 - 10 m for Osoyoos Lake, 2001

Year	Month	Site 1	Site 2	Site 3	Site 4
2001	J				
	F				
	M				
	A				
	M		3.6	5.4	9.3
	J		4.4	7.9	13.1
	J		4.8	10.3	13.4
	A		5.0		
	S		6.5	9.5	8.3
	O				
	N				
	D				

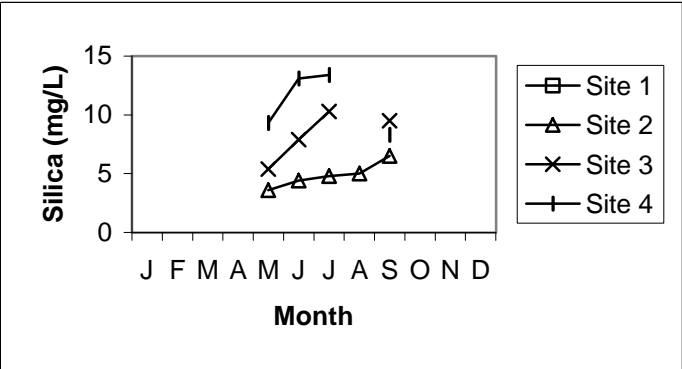


Figure 16f: Silica Levels at 20 m for Osoyoos Lake, 2001

Year	Depth	Month	Site 1	Site 2	Site 3	Site 4
2001	Deep	J				
		F				
		M				
		A				
		M		3.9	5.8	13.0
		J		4.7	8.9	14.3
		J		5.6	10.8	13.8
		A		6.7		
		S		8.1	10.5	11.3
		O				
		N				
		D				

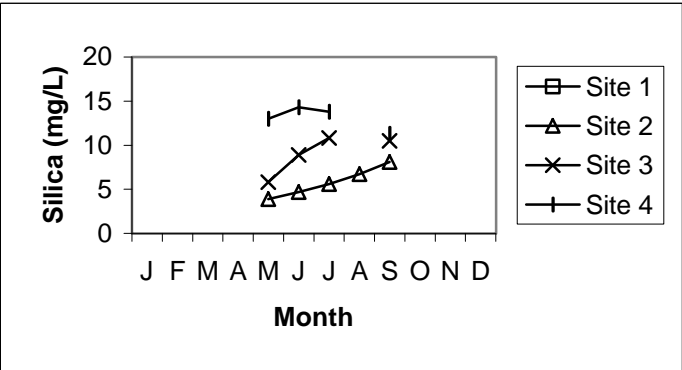


Figure 16g: Silica Levels at Deep Sections for Osoyoos Lake, 2001

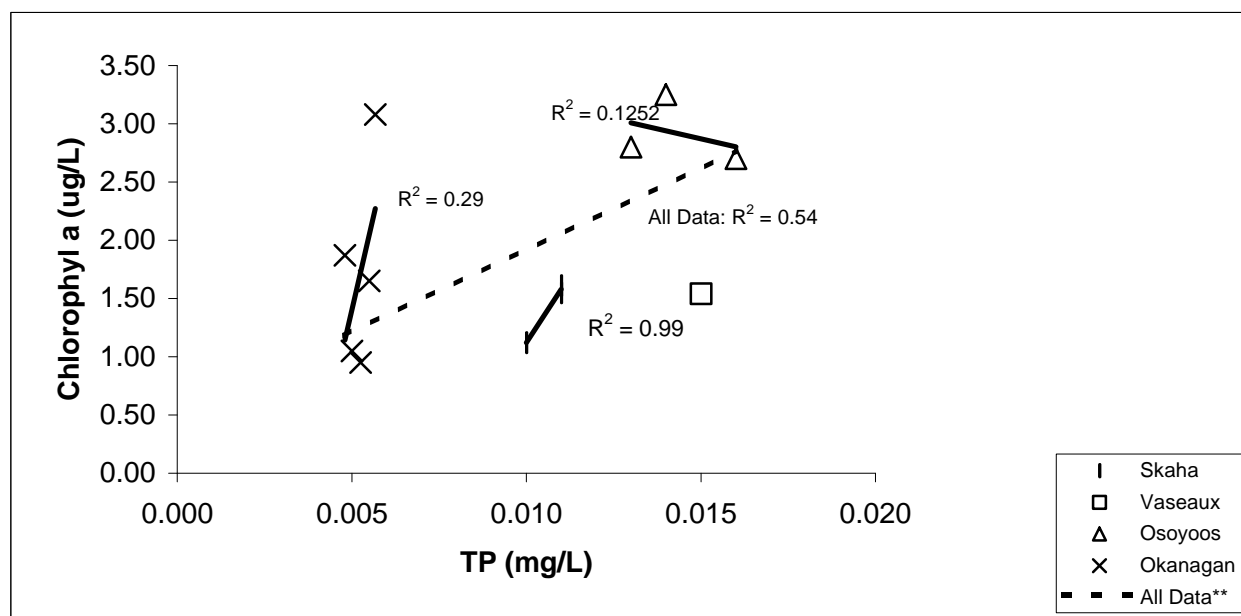
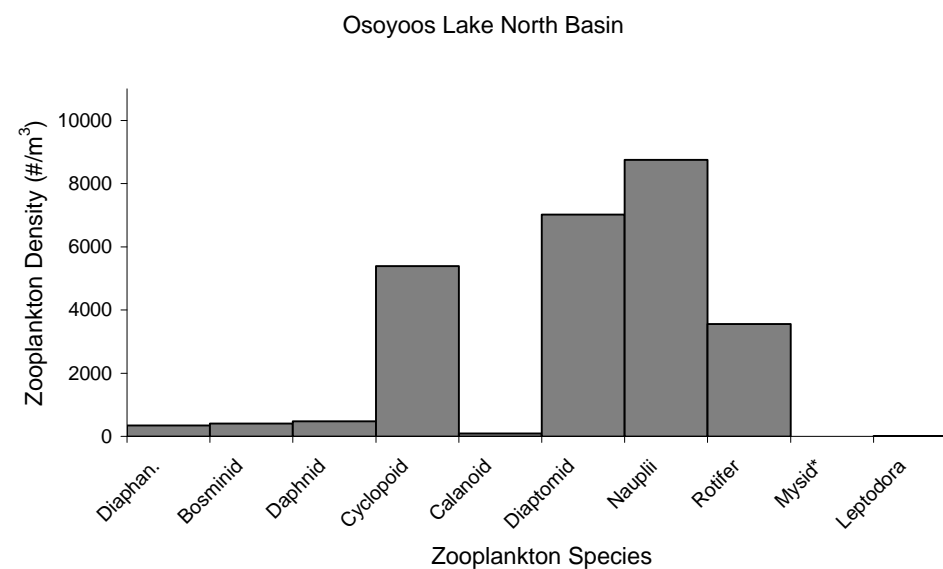
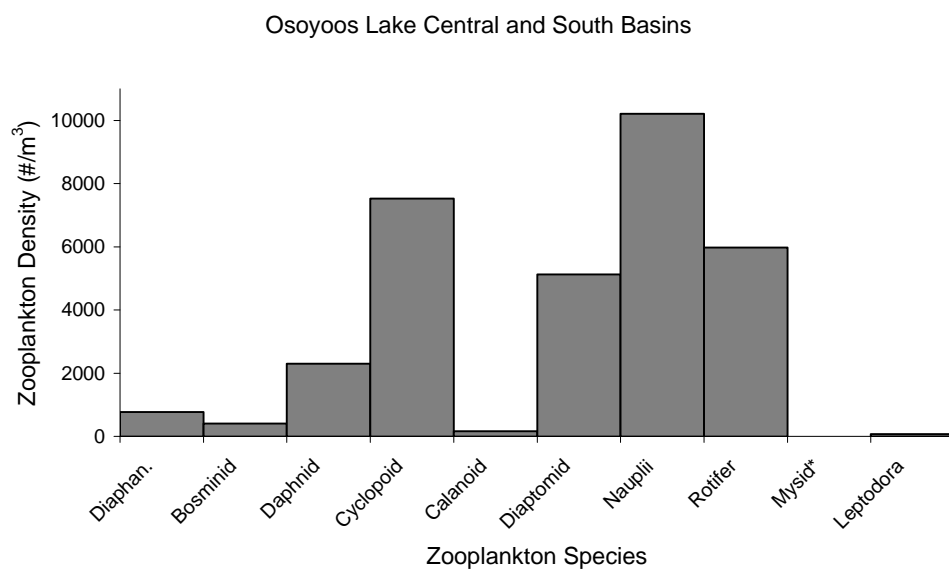
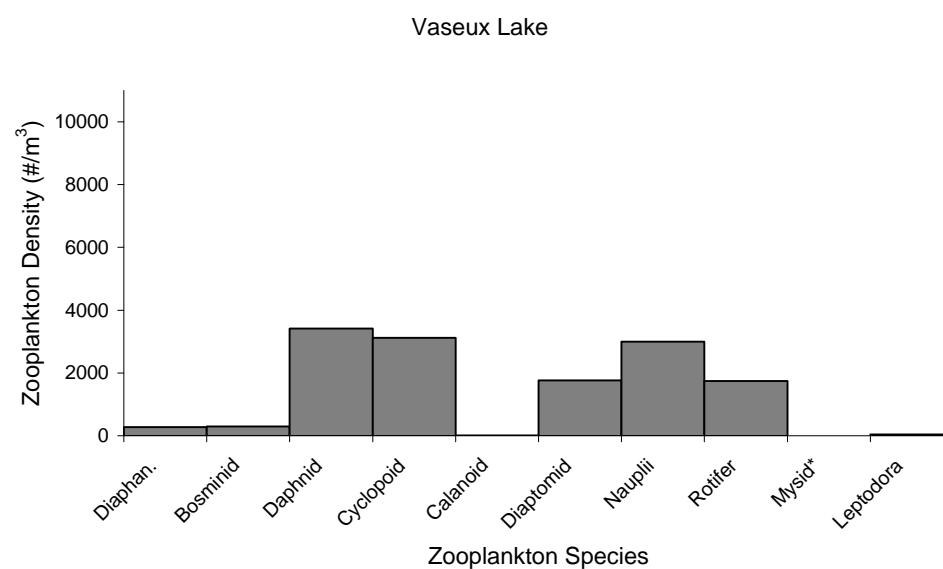
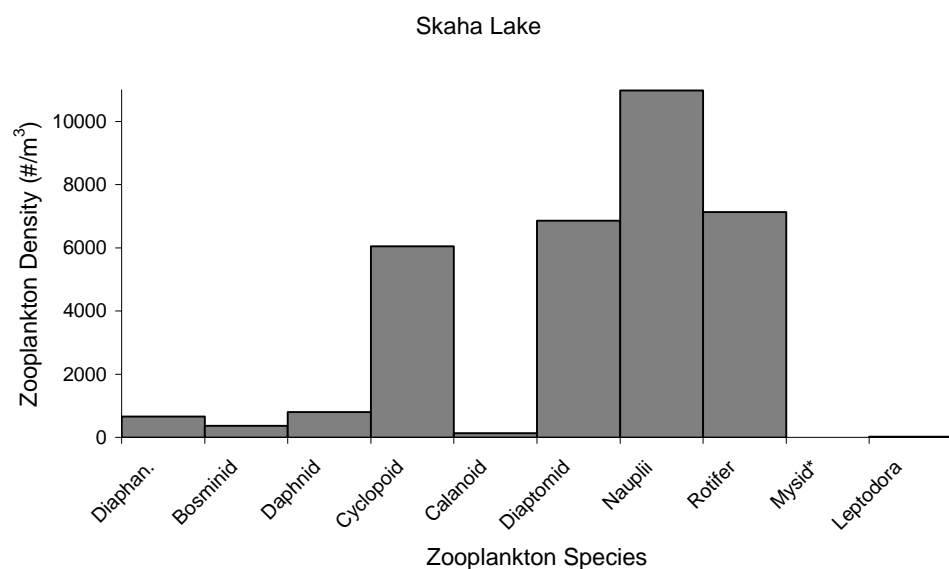


Figure 17: Total Phosphorous:Chlorophyll a Ratio at 0-10m for Skaha Lake, Vaseaux Lake, Osoyoos Lake, and Okanagan Lake, 2001

Lake	Site	TP	Chlorophyll a	Comments
Skaha	1	0.011	1.55	May-September Average
	2	0.010	1.12	May-September Average
	3	0.011	1.61	May-September Average
Vaseaux	1	0.015	1.54	May-September Average
Osoyoos	2	0.016	2.70	May-September Average
	3	0.013	2.80	May-September Average
	4	0.014	3.25	May-September Average
Okanagan	ok1	0.005	1.87	June-September *
	ok2	0.005	1.05	September only *
	ok4	0.006	1.65	August and September *
	ok6	0.005	0.95	June-September *
	ok7	0.006	3.08	June, July, and September *

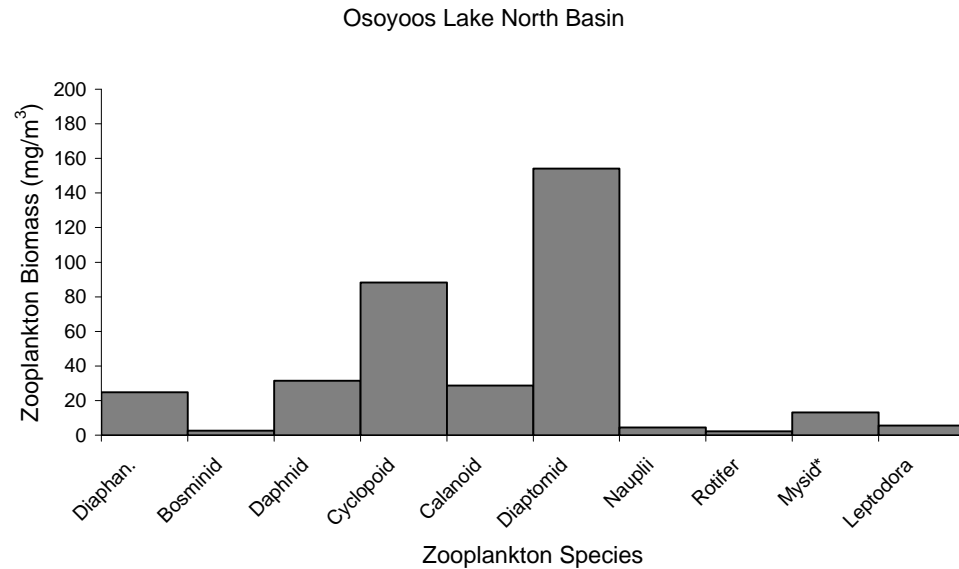
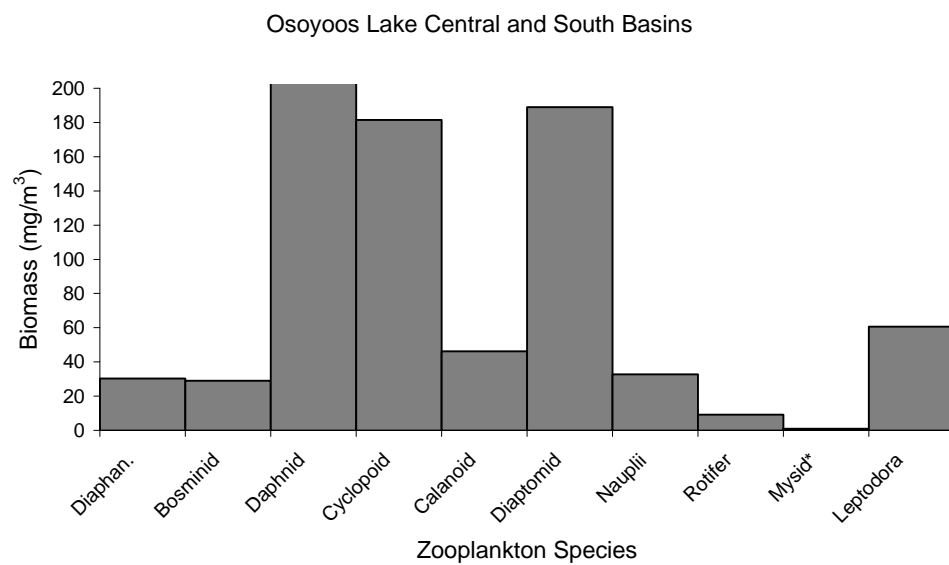
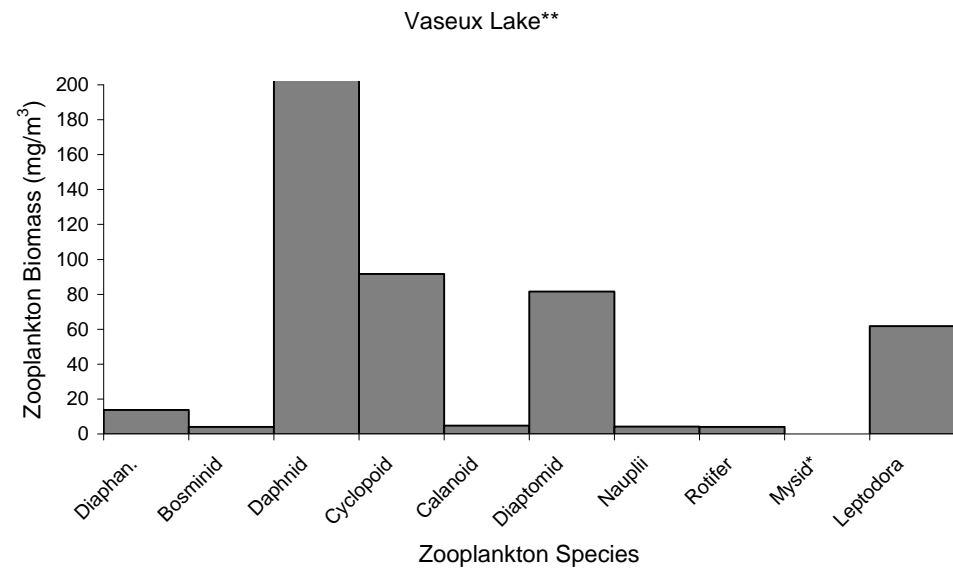
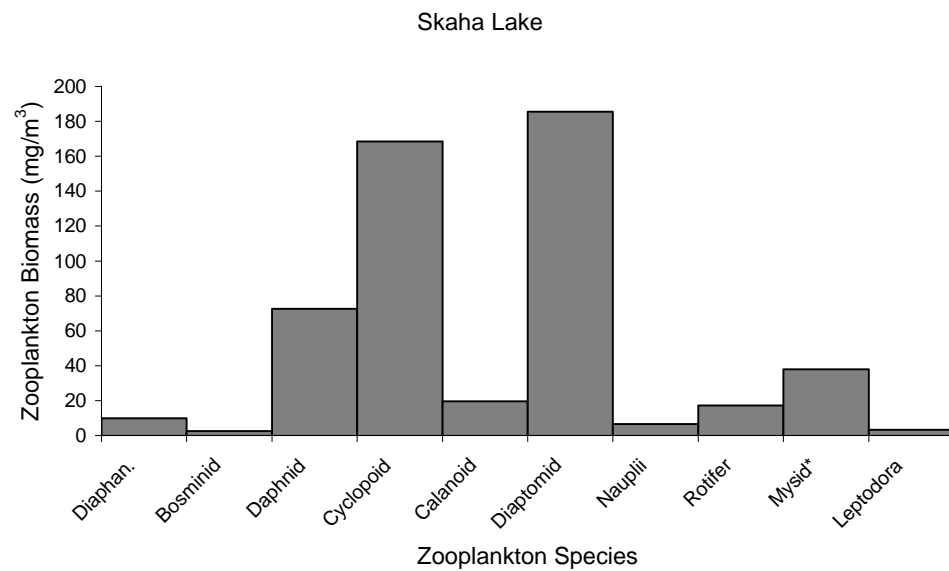
*indicates prov. Data pooled

**Vaseaux Lake and ok7 site excluded



*Mysid vertical haul sampling conducted separately with 300 micron net

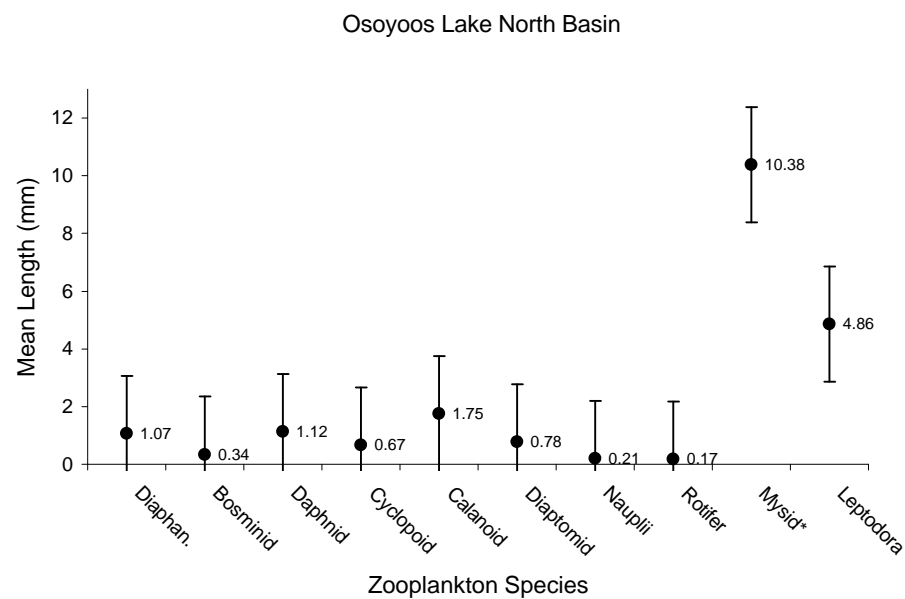
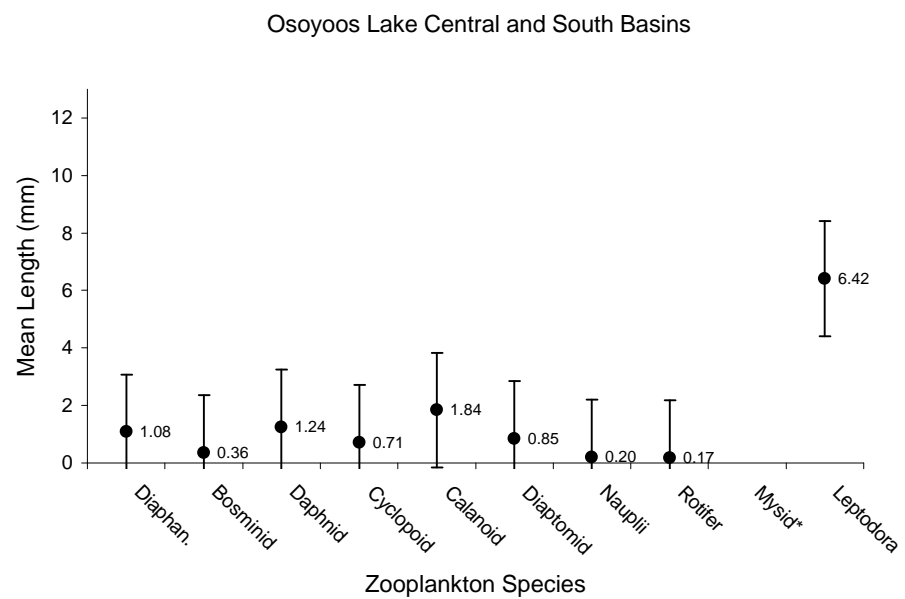
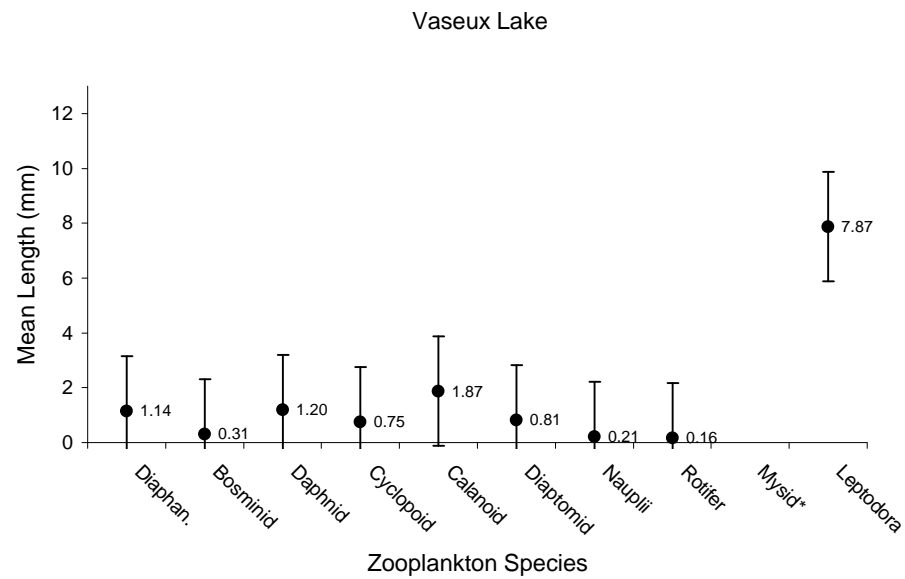
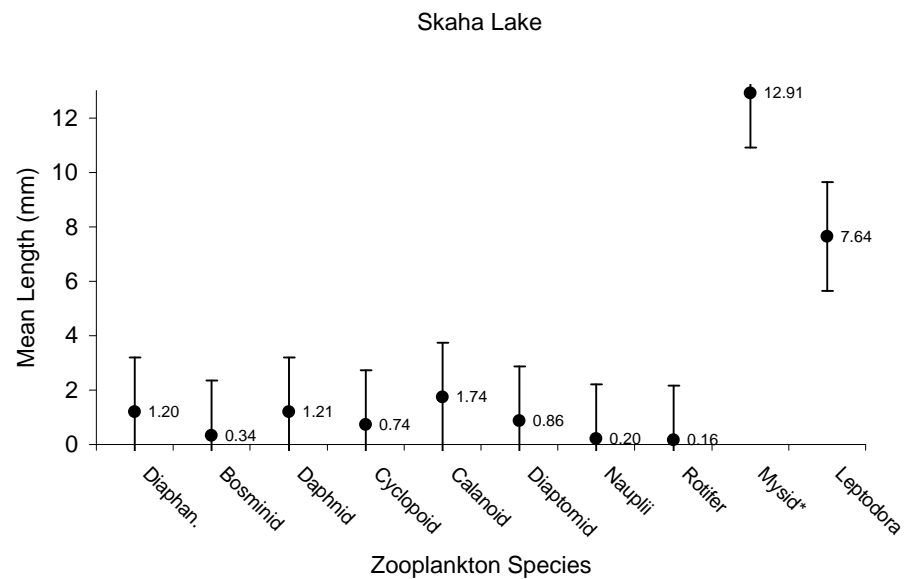
Figure 18: Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin Zooplankton Community Structure:



*Mysid vertical haul sampling conducted separately with 300 micron net

**Note Vaseux Lake Daphnid 527 mg/m³

Figure 19: Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin Zooplankton Community Structure: Species Composition by Biomass Seasonal Average (May-November)



*Mysid vertical haul sampling conducted separately with 300 micron net

Figure 20: Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin zooplankton mean length

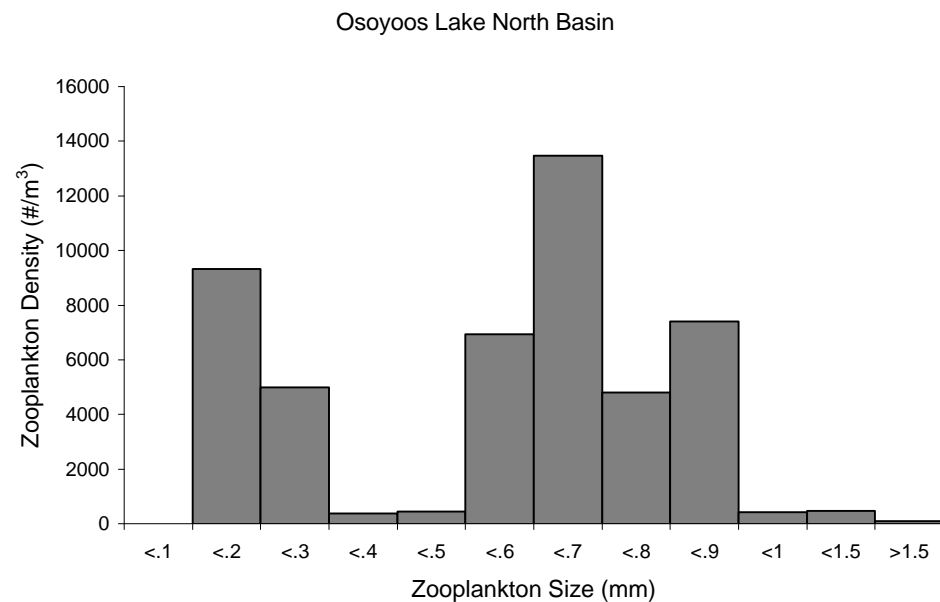
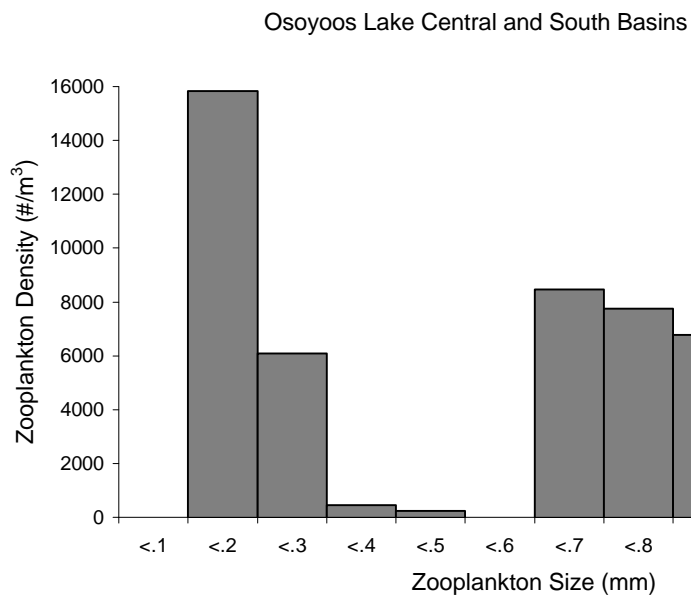
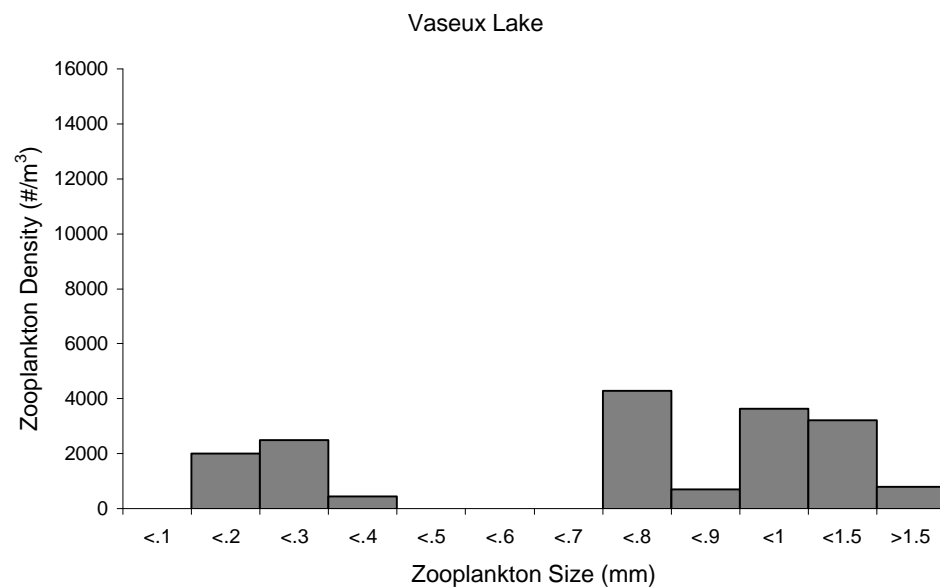
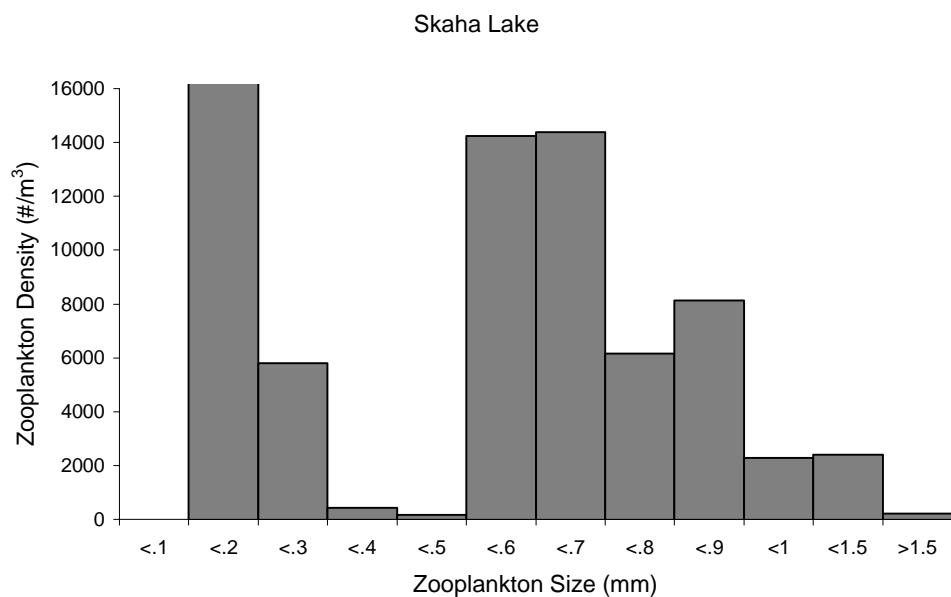


Figure 21: Skaha Lake, Vaseux Lake, Osoyoos Lake Central and South Basins, Osoyoos Lake North Basin zooplankton density by size frequency seasonal average (May-November).

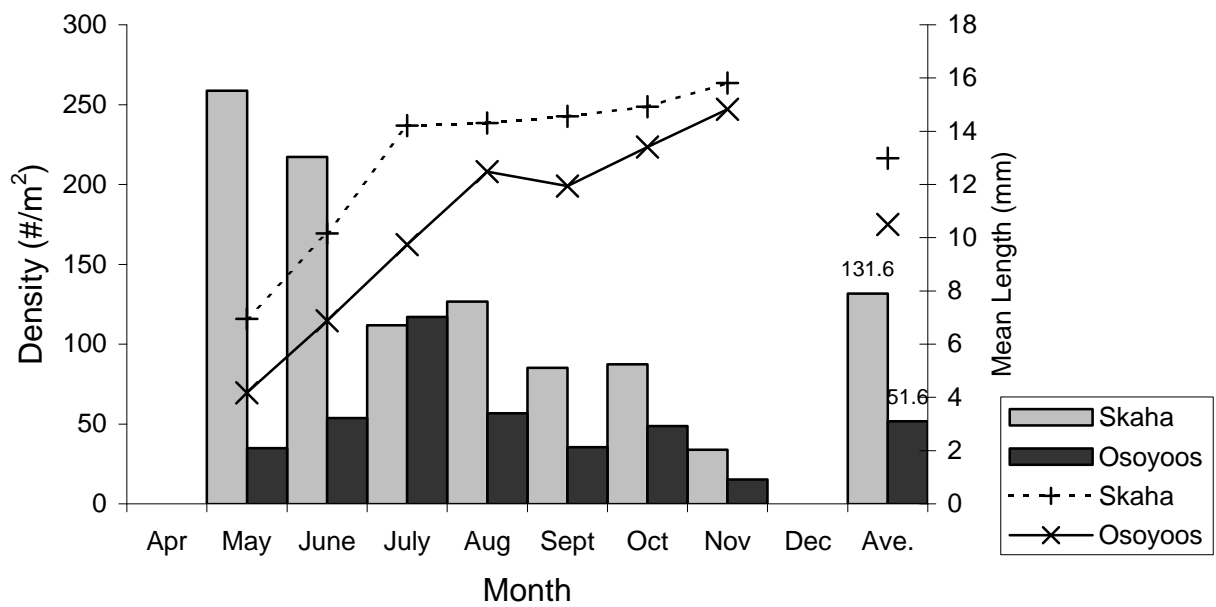


Figure 22: *Mysis relicta* densities and mean length (May-November 2001) in Skaha Lake and North Basin of Osoyoos Lake

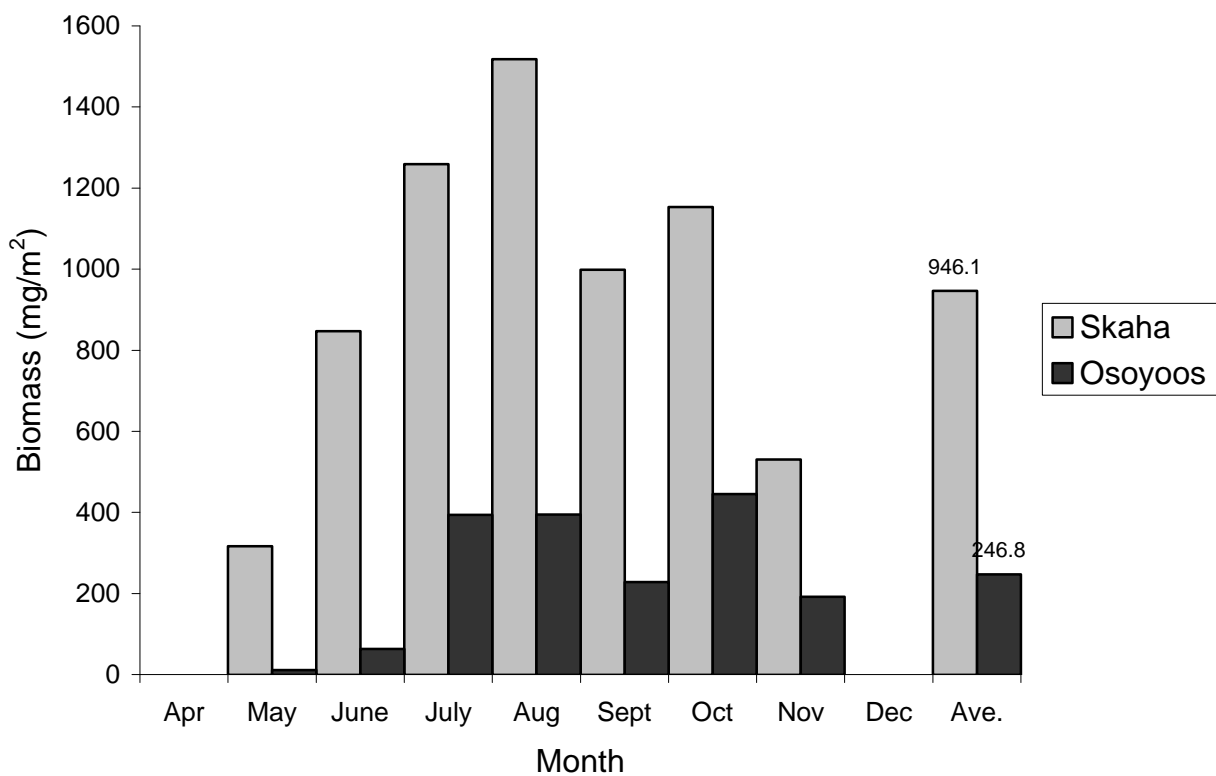


Figure 23: *Mysis relicta* biomass (May-November 2001) in Skaha Lake and North Basin of Osoyoos Lake

OBJECTIVE 4

Literature review

Interaction of kokanee and Rainbow trout with exotic species
identified as being present in the Okanagan system below
McIntyre Dam but not above.

YEAR 2 OF 3

Submitted to: Chris Fisher
Colville Confederated Tribes

Submitted by:
Okanagan Nation
Fisheries Commission

Prepared by:
Howie Wright

April 2002

Executive Summary

The Okanagan River sockeye of the Columbia River system, considered to have once populated distant upstream water, are currently restricted to those below McIntyre Dam near Vaseux Lake. An initiative is now being considered to reintroduce the run to upstream areas, but there is concern that in the process, undesirable exotic species could have been given access to the detriment of valued resident, as well as reintroduced fish species. As part of studies undertaken by Okanagan Nation Fisheries Commission and Colville Confederated Tribes a literature review was undertaken to gain insights into possible reintroduction risks.

The literature review identifies and assesses potential interactions of Kokanee (*Oncorhynchus nerka*), and Rainbow Trout (*Oncorhynchus mykiss*) with exotic species of the Okanagan River system below, but not above McIntyre Dam. While apparently relatively little pertinent material exists in the published literature, some life history and habitat overlaps were confirmed, and other possible ones were found.

No overlaps were found in habitat requirements or interactions between kokanee and rainbow trout on one hand and tench (*Tinca tinca*) or goldfish (*Carassius auratus*) on the other. However black crappie (*Pomoxis nigromaculatus*) longer than 16 cm may eat juvenile kokanee or rainbow trout when they first emerge from the gravel or as they migrate to the pelagic zone of the lakes, and black bullhead (*Ameriurus melas*) and brown bullhead (*A. nebulosis*) may consume kokanee eggs spawned on beaches.

Largemouth bass (*Micropterus salmoides*), particularly those 8-20cm, are potential predators on emergent and migrating juvenile kokanee and trout though low water temperatures may be a moderating factor. They may also eat adult kokanee. Walleye (*Stizostedion vitreum*) was the exotic species found to have the most interactions with both kokanee and rainbow trout both as predators on age 0+ fish, and as competitors for food.

Bluegill (*Lepomis macrochirus*) can have periods of pelagic lake residence both as juveniles until about 12.5 mm in length, and – in shallow lakes at least – again at adult life stages. Their behaviour should they inhabit larger Okanagan Valley lakes is a matter of speculation but they would likely compete for food of both juvenile salmon and trout.

Probably the most effective means of managing exotic species is to restrict their access. At present the risk of their invasion is likely greater through deliberate unauthorized introductions than as a result of initiatives to re-establish sockeye salmon in Skaha Lake. Several recommendations for further work identified during the literature review are as follows:

- Stomach analyses of largemouth bass (particularly 80-200mm in length) captured at the time of sockeye fry above Osoyoos Lake.
- Further literature search for evidence that bluegill will use the pelagic zones, and sampling (in the final year of exotic species sampling) to confirm its relevance to Okanagan basin circumstances
- -Continue sampling for walleye in Osoyoos Lake, and if found, undertake further work to assess its implications for the program.
- Literature review of the leaping abilities of Exotic Species of Concern as an aid in developing and/or refining fish passage ladders.

Table of contents

Executive Summary.....	i
Table of contents	ii
List of Tables	ii
1.0 Introduction	1
2.0 Methods	1
3.0 Results and Discussion	2
3.1 Kokanee (<i>Oncorhynchus nerka</i>) life history	2
3.2 Potential for Exotic Species Interactions	3
3.2.1 Tench (<i>Tinca tinca</i>)	3
3.2.2 Black Crappie (<i>Pomoxis nigromaculatus</i>)	3
3.2.3 Black bullhead (A.m) and Brown bullhead (A.n.)	3
3.2.4 Largemouth bass (M.s).....	3
3.2.5 Walleye (<i>Stizostedion vitreum</i>).....	4
3.2.6 Goldfish (<i>Carassius auratus</i>).....	5
3.2.7 Bluegill (<i>Lepomis macrochirus</i>)	5
3.3 Rainbow Trout life history	6
3.4 Potential for Exotic Species Interactions	7
3.4.1 Tench and Goldfish.....	7
3.4.2 Black crappie	7
3.4.3 Black bullhead and brown bullhead.....	7
3.4.4 Largemouth bass	7
3.4.5 Walleye	7
3.4.6 Bluegill.....	7
4.0 Summary and Recommendations	8
5.0 Works Cited.....	10

List of Tables

Table 1. Names and distribution of Exotic Species of Concern reported from the Okanagan Basin below McIntyre Dam. (Adapted from (Anonymous 2001)).....	1
Table 2. Summary of Possible Interactions between Kokanee (<i>Oncorhynchus nerka</i>) and Exotic Species of Concern.....	8
Table 3. Summary of Possible Interactions between rainbow trout and Exotic Species of Concern in the Okanagan River system.....	9

1.0 Introduction

The Okanagan River sockeye run, which may have populated much of the upper drainage in the past, currently limited to waters below McIntyre Dam near Vaseux Lake. It is one of the last significant runs in the Columbia River basin and resource managers have recently set a long-term goal of reintroducing it into the upper drainage. Existing spawning and rearing areas will probably need to be increased in the process. It has now been proposed to reintroduce the population into Skaha Lake as a first, and somewhat experimental step.

The Okanagan Nation Fisheries Commission (ONFC) and the Colville Confederated Tribes (CCT) have completed Year 2 of an evaluation of the reintroduction proposal, and one of the principal concerns is that measures undertaken to allow sockeye to migrate farther upstream, might also allow certain exotic species (here termed Exotic Species of Concern) to also move into upstream waters beyond their present range, and diminish production of valuable kokanee (*Oncorhynchus nerka*), and rainbow trout (*Oncorhynchus mykiss*) populations and possibly other valued resident fishes.

A literature review of the life history and habitat requirements of Exotic Species of Concern was undertaken as a first step in addressing this worry and is reported here.

2.0 Methods

Published requirements of kokanee and rainbow trout were compared with those of certain exotic species identified in Year 1 (Task 2a) of the program and found only downstream of McIntyre Dam. (See Table 1 for a list of those fishes). Walleye (*Stizostedion vitreum*) is thought not to be in the Okanagan but is present in the Columbia River mainstream, and because of its record of aggressive colonization it has been included in the list. Bluegill found recently in Osoyoos Lake was also included.

Table 1. Names and distribution of Exotic Species of Concern reported from the Okanagan Basin below McIntyre Dam. (Adapted from (Anonymous 2001))

Exotic Species	Scientific Name	Known or Reported Distribution
Tench	<i>Tinca tinca</i>	Unconfirmed reports from Kalamalka Lake and Okanagan Lake
Black crappie	<i>Pomoxis nigromaculatus</i>	Caught in Osoyoos Lake by ONFC
Black Bullhead	<i>Ameriurus melas</i>	Reports from Osoyoos Lake
Brown Bullhead	<i>Ameriurus nebulosis</i>	Unknown
Largemouth bass	<i>Micropterus salmoides</i>	
Walleye	<i>Stizostedion vitreum</i>	
Goldfish	<i>Carassius auratus</i>	
Bluegill	<i>Lepomis macrochirus</i>	Caught in Osoyoos Lake by ONFC

3.0 Results and Discussion

3.1 Kokanee (*Oncorhynchus nerka*) life history

Andruska and Sebastian (2000) provide the most recent summary of historical kokanee information for Okanagan Lake, and is the main source presenting kokanee life history and habitat requirements. Little is known of the relatively small Skaha Lake population but numbers spawning are recorded annually and the population is considered to be depressed (Mathews 2001)

Kokanee spawn in September and October, and two populations units - stream spawners and beach spawners – have been identified (Andrusak and Sebastian 2000; Scott and Crossman 1998; Shepherd 1990). These units are thought to differ in size and age at maturity (Shepherd 1990) and usually have some separation as to spawning time.

Okanagan Lake stream spawners first appear in late August with the peak occurring during the late September and early October. Northern tributary spawners are inclined to peak latest (Andrusak and Sebastian 2000). Beach spawning generally occurs in October and ends early November.

The preferred substrate of stream spawners is rounded gravel less than 5 cm in diameter, but it should be noted that more than 90% of the historic spawning substrate is angular rip-rap more than 5cm in diameter, where the fish spawn at depths of less than one meter and without any apparent pairing such as occurs in streams (Shepherd 1990). There are thought to be suitable spawning opportunities at greater depth in the lake, but thus far none has been discovered (Andrusak and Sebastian 2000).

The time from egg deposition to 100% hatch varies from 48 days at 15°C to 140 days at 4°C (Scott and Crossman 1998). It is thought that kokanee fry migrate directly to the lake pelagic zone after emergence (Matthews 2001)

The principal food of kokanee is pelagic zooplankton and insects (Burgner 1991). Adults usually attain fork lengths of about 203-229 mm (Scott and Crossman 1998) though in 1987 sampled beach spawners and stream spawners had an average fork lengths of 250 mm and 389 mm respectively (Shepherd 1990).

According to Andrusak and Sebastian (2000), kokanee less than 250mm length utilizes copepods and cladocerans almost exclusively, while larger fish eat mysis relicta. In summer the fish undergo a diel vertical migration, ascending into the top 20m of the water column at dusk, and returning to depths of about 80m at dawn.

The foregoing can be used as a basis for assessing possible predation and competition with the following exotic species:

3.2 Potential for Exotic Species Interactions

3.2.1 Tench (*Tinca tinca*)

Tench are primarily sluggish, bottom feeding fish, which inhabit the littoral zone of lakes and other swampy waters. They would most likely compete for food with some native species (Anon 2001). No further evidence was found for interaction with kokanee.

3.2.2 Black Crappie (*Pomoxis nigromaculatus*)

Black crappie inhabit low gradient, shallow waters. After reaching about 160 mm in length they consume a variety of small fishes which constitute an increasing proportion of their diets even though plankton continue to be eaten. They are native to the backwaters and tributaries of the Columbia River in well-vegetated areas. (Anon 2001)

No further evidence was found for interaction with kokanee. However, as black crappie exceed 160mm in length they become piscivorous and would probably feed on kokanee during their emergence and migration to the lake.

3.2.3 Black bullhead (*A.m*) and Brown bullhead (*A.n.*)

Black and brown bullheads prefer quiet murkey, soft-bottomed areas and are primarily bottom feeding scavengers. Both species compete with other bottom feeders for food but probably interact very little with salmon (Anon. 2001).

No further evidence was found evidence of bullhead and kokanee interaction found. Bullheads have been known to consume some eggs of trout and cisco (Anon 2001), and some consumption of uncovered or eroded beach spawning kokanee eggs seems likely.

3.2.4 Largemouth bass (*M.s*)

Largemouth bass inhabit upper warmer waters where kokanee juveniles are not usually found. They are known as “ambush predators” and this behaviour tends to minimize their impact on pelagic species in general. However they may compete with sport fish species for food or space, and like walleye they may tend to target fish of a smaller size not usually harvested by sport fishermen (Anon 2001).

Largemouth bass may feed on kokanee fry immediately after emergence, and as they migrate through the littoral to the pelagic zone, through field observations, acoustic surveys and trawling have shown that newly emergent Okanagan Lake kokanee spend little or no time in the littoral. (Mathews 2001). In some other river systems anadromous sockeye do spend time in the littoral prior to moving into the pelagic zone and may then be subject to largemouth bass predation (Burgner 1991).

Largemouth are piscivorous at lengths of 80-120mm (Werner et al 1977). They prefer cover in aquatic vegetation where prey is abundant. Their ability to distinguish between prey species allows them to modify their attack behaviour accordingly (e.g. ambush or pursue) (Savino and Stein 1989).

One might expect that largemouth greater of 80 to 200mm would feed on kokanee during emergence. However, relevant studies of a different species (juvenile anadromous herring) in

a different lake environment found that largemouth greater than 200mm rejected the herring presumably because of their small size and low bioenergetic value (Yako and Mather 2000). Herring were not found in bass stomachs until summer even though they were available in spring (Yako and Mather 2000).

Low spring temperatures could also limit predation in the Okanagan basin since largemouth have been found not to feed when water temperatures are below 10°C (Wahl 1985). Andrusak (2000) found that Okanagan Lake springtime water temperatures did not exceed 7°C during 1977-1999, so one might expect that in some years at least largemouth bass would not be feeding during much or all of the period when kokanee emerge and migrate to the pelagic zone.

Theoretically largemouth bass should be able to consume fish of about 29% of their own length but they have been known to eat prey as much as 50% of their own length, (Yako and Mather 2000). Largemouth were not inhibited by the presence of spines on prey species (Webb 1986). These observations would suggest that large adult bass could prey successfully on smaller specimens of adult kokanee (most likely during spawning migration). However, an abundance of other littoral prey species and short periods of potential interaction could minimize such occurrences.

In conclusion, the reviewed literature suggests that any interaction between largemouth bass and kokanee would occur during periods of juvenile migration to the pelagic zone and/or adult migration to spawning areas, but that any such interaction would likely be small as both water temperature and low food value issues could be limiting.

3.2.5 Walleye (*Stizostedion vitreum*)

Walleye are known piscivorous found in the pelagic and littoral zones of lakes where they can have overlapping habitat preferences with juvenile sockeye and could prey heavily upon them. Because walleye also feed on kokanee they, among all the exotic species, may be the greatest potential threat to Okanagan kokanee and sockeye populations. Walleye predation on sockeye smolts would be hard to mitigate since most predacious walleye are smaller than those caught by anglers and walleye, as they age, eat fewer smolts (Anon 2001).

Walleye inhabit both the Columbia River mainstem and its reservoir system and it is likely that they could adapt to conditions in Osoyoos Lake (anon 2001). While walleye feed on juvenile anadromous sockeye in river and reservoir systems during smolt migration, they appear to prefer sculpins, cyprinids and suckers (Zimmerman also noted that northern pike minnow consumed more, than either smallmouth bass or walleye.

Adult walleye are particularly photo-sensitive, living in deep water in summer and moving inshore in fall (Anon 2001). They select prey less than 130mm in length even as adults (Knight and Vondracek 1993). Spawning occurs on shoals in lakes and in rivers and smaller streams shortly after ice break-up. They choose boulders or coarse gravel substrate and water depths of 0.05- 4.6m in lakes and 0.2-0.9m in rivers (Anon 2001). After spawning there would be a high food demand – at about the same time that kokanee fry emerge. This suggests that walleye would prey on kokanee recently emerged, or while migrating to the lake, as well as on older individuals- with possible emphasis on fish of age 0+.

Larval walleye are pelagic and photo-positive, occupying waters 0.3-1.2 m deep until about 2.5-4.0cm in length (Anon 2001). Juveniles have been known to select *Daphnia* as food (Slipke and Duffy 1997) and consequently could be competitors with kokanee juveniles in the pelagic zone. However walleye are concentrated in the upper layers while kokanee have greater vertical distribution. In addition, given their respective times of incubation and emergence, kokanee would likely be feeding for about a month prior to the time when walleye could become a threat.

3.2.6 Goldfish (*Carassius auratus*)

Goldfish are most successful in smaller water bodies, which have a good growth of aquatic plants. Like common carp they are prolific and deleterious to native fish because they increase water turbidity and uproot and destroy submerged vegetation, which provides cover, food and spawning sites for native species (Anonymous, 2001). This review found no further evidence for interaction with kokanee.

3.2.7 Bluegill (*Lepomis macrochirus*)

Bluegills can alternate between littoral and pelagic zones of lakes throughout their lives. After hatching in the littoral zones of small lakes they migrate to the pelagic where they feed on zooplakton for a time. At about 125mm in length they return to the littoral and spent several years feeding there. Keast (1985) indicates that bluegills prefer larger zooplankton.

3.3 Rainbow Trout life history

In general rainbow trout are spring spawners, mainly during mid-April to late June but sometimes extending from March to August. Spawning usually occurs in fine gravel in a riffle above a pool and at water temperatures of 10.0 – 15.5°C. Sexual maturity can occur in males as early as one year of age and 9 in females as late as 6 years in males and as late as 6 years of age. On average, it occurs at 3-5 years (sexes combined) (Scott and Crossman 1998).

Okanagan lake rainbows usually spawn at 3-6 years, with a maximum of 8 years of age (sexes combined), they have never been observed to spawn in the lake itself and less than 25% of individuals are estimated to engage in repeat spawnings (Shepard 1990).

Scott and Crossman (1998) observe that rainbow trout males tend to be aggressive on the spawning grounds where a dominant male and a number of “peripheral” males court one female. The female may dig several redds in association with the same, or different males, depositing an average of 800 – 1000 eggs per redd. When eggs and milt have been deposited the female covers the egg pit with gravel. Eggs hatch in 4 – 7 weeks and fry remain in the gravel while nourished by the yolk sac for about 3-7 days until they emerge from mid June to mid-August. These authors note that the average fecundity of females in the Interior of British Columbia is 1366-2670 eggs.

When rainbow trout emerge from the gravel they could migrate immediately to a lake, remain in the natal stream until fall or remain in the stream from one to three years. In the stream environment they are known to feed on plankton, crustaceans, insects, snails, leeches, fish and eggs (Scott and Crossman 1998).

In the Okanagan Basin, Pinsent (1974) concluded that approximately 50% of the lake dwelling rainbow trout live in the streams for at least their first year and a later study indicated an exit after 1-2 years (Shepard 1990). Stream dwelling rainbow trout of all ages prefer the pool and riffle areas. A minimum flow of at least 3 cu.ft/sec is deemed necessary to prevent water temperatures from reaching an undesirable 18-20°C (Koshinsky 1972).

Fry, which migrate to Okanagan Lake, become pelagic as adults. It has been thought that two populations, littoral and pelagic, existed but Shepherd (1990), considers this unlikely. Furthermore, 4 sessions of electrofishing in year 2000 in Osoyoos, Skaha and Okanagan Lakes captured only 5 rainbow trout in the littoral zones (Anonymous 2001) and this could be further evidence that a distinctly littoral population is unlikely.

Okanagan Lake resident rainbow trout are pelagic, feeding on zooplankton until they are large enough to consume fish, at which time kokanee become the principle prey.

3.4 Potential for Exotic Species Interactions

Most reviewed studies were concerned with impacts of existing fish populations on introduced rainbow trout in eastern North America, and the possible need to remove the resident fish prior to stocking (Fraser 1978), (Hodgson et al. 1991), (Marrin and Erman 1982).

3.4.1 Tench and Goldfish

This literature review found no instances of interactions of tench or goldfish with rainbow trout. However these exotic fishes would, like carp increase turbidity and destroy aquatic vegetation, neither of which would be likely to affect rainbow trout.

3.4.2 Black crappie

black crappie greater than 160mm in length are piscivorous and could feed on rainbow trout during the trout's emergence and migration to the lake.

3.4.3 Black bullhead and brown bullhead

Black and brown bullheads are known to have only a minor impact on trout and cisco by eating their eggs and would therefore not be a significant threat to rainbow trout. Furthermore rainbow trout habitat is largely unsuited to bullheads.

3.4.4 Largemouth bass

Little interaction would occur between rainbow trout and largemouth bass because of their different habitat preferences. Overlap would occur during rainbow trout emergence and migration to pelagic zone. Migration size of rainbow trout will depend on if they remain in the stream for 1-2 years or immediately migrate to the lake. As identified with kokanee, the small body size and low bioenergetic value of rainbow trout that emerge and immediately migrate to the lake may not be preferential prey for largemouth bass. However, unlike kokanee, temperature would not be a factor as rainbow trout emerge and migrate in the summer months.

3.4.5 Walleye

Angler's catches of rainbow trout in a stocked lake underwent a five-fold reduction when walleye were introduced. Significantly, spring introductions of rainbow juveniles coincided with the presence of spawned walleye (Yule et al 2000). However, even as adults, Walleye selected prey less than 130mm long (Knight and Vondracek 1993), so they would be expected to target newly emerged trout migrating to the lake, and age 0+ trout in the pelagic zones. Walleye and rainbow trout would also be competitors for food both when planktivorous as juveniles and when piscivorous as adults – particularly when walleyes are feeding in the pelagic zones.

3.4.6 Bluegill

Bluegill and rainbow trout compete for both food and space from the time of emergence until bluegill are about 12.5mm long and again when they are more than 80 mm long. However it is not known whether they would exhibit the same behaviour in local lakes as noted elsewhere.

4.0 Summary and Recommendations

It is hoped that this literature review, summarized in Tables 2 and 3 has identified the most likely interactions between kokanee and rainbow trout, and exotic fish species of concern.

Except for walleye, there appears to be little potential for interactions of Exotic species of Concern with either kokanee or rainbow trout. Walleye predation would most likely influence prey community structure (Wahl 1985). Knight and Vondracek (1993) also found that in Lake Erie walleye changed prey structure, but not prey abundance, and like Lyons (1987) they thought changes in prey species composition occurred because of walleye preference for soft rayed fish. However these conclusions were from experiments in enclosures under natural conditions the most abundant or vulnerable species were selected even if they were spiny rayed (Lyons 1987; Porath and Peters 1997).

Based upon habitat preferences identified in a recent study, warm water species found below N McIntyre Dam (but not above it) would likely have temperature induced feeding limitations (anonymous 2001). This may explain the fact that in more northerly climates the range of largemouth bass is limited to waters that warm quickly in spring and cool slowly in fall (Hamilton and Powles 1979).

Table 2. Summary of Possible Interactions between Kokanee (*Oncorhynchus nerka*) and Exotic Species of Concern

Exotic Species	Possible Kokanee Interaction
Tench	None Identified
Black crappie	Larger than 160 mm they can be piscivorous and likely prey on O.n. as they emerge and migrate to the lake.
Black bullhead	Known to consume trout and cisco eggs occasionally; would eat beach spawned O.n. eggs if not well covered.
Brown bullhead	Known to consume trout and cisco eggs occasionally; would eat beach spawned O.n. eggs if not well covered.
Largemouth bass	Would prey on juvenile O.n. at emergence and during migration through the littoral, and on small adults migrating to spawning areas.
Walleye	Would prey particularly on small O.n. emerging and migrating, and probably on larger juveniles and adults with emphasis on age 0+ fish
Goldfish	None identified
Bluegill	Juveniles to lengths of about 12.5 mm likely to compete with O.n. juveniles for food if suspected pelagic behaviour is confirmed.

Table 3. Summary of Possible Interactions between rainbow trout and Exotic Species of Concern in the Okanagan River system.

Exotic Species	Potential Rainbow Trout Interaction
Tench	None identified
Black crappie	Larger than 160 mm they can be piscivorous and likely prey on O.m. as they emerge and migrate to the lake
Black bullhead	None identified.
Brown bullhead	None identified.
Largemouth bass	Would prey on O.m. after emergence and on those migrating to the lake at age 0+. Adults would compete with O.m. adults for food.
Walleye	Would prey on newly emergent O.m. and on those migrating to the lake at age 0+. Adults would compete with O.m. adults for food.
Goldfish	None identified
Bluegill	Juveniles to lengths of about 12.5mm likely to compete with O.m. juveniles for food if suspected pelagic behaviour is confirmed.

Introduced exotic species will undoubtedly have some effects, e.g. “predation competition, disease introduction, genetic interactions and habitat modification... (and) change the amount of forage available to native species by direct predation or by evoking a change in prey distribution and habitat selection” (Weidel et al 2000). In a littoral community in two small Michigan lakes segregation among Centrarchids and Cyprinids was primarily by habitat partitioning.

Probably the most effective means of managing impacts of exotic species is to restrict their access. However the risk of colonization by intentional (unauthorized) introductions of exotic species is likely to be greater than that resulting from measures taken to achieve re-introduction.

Some further investigations as prioritized below are recommended as a means of clarifying some aspects of the information extracted during the literature review.

- Stomach analyses of largemouth bass (particularly 80-200mm in length) captured at the time of sockeye fry emergence above Osoyoos Lake.
- Further literature search for evidence that bluegill will use the pelagic zones, and sampling (in the final year of exotic species sampling) to confirm its relevance to Okanagan basin circumstances
- Continued sampling for walleye in Osoyoos Lake, and if found, further work to assess its implications for the program.
- Literature review of the leaping abilities of Exotic Species of Concern as an aid in developing and/or refining fish passage ladders.

5.0 Works Cited

- Andrusak, H., et. al. 2000. Okanagan Lake Action Plan Year 4 (1999). Pages 325pp. *in* Fisheries Project Report RD 83. Ministry of Water, Land and Air Protection, Victoria.
- Andrusak, H., and D. Sebastian. 2000. Okanagan lake kokanee biology. Pages 183-236 *in* H. Andrusak, et. al., editor. Okanagan Lake Action Plan Year 4 (1999). Fisheries Management Branch, Ministry of Agriculture, Food and fisheries, Province of British Columbia, Victoria.
- Anonymous. 2001. Evaluation of an Experimental Re-Introduction of Sockeye Salmon into Skaha Lake-Year 1 of 3. Okanagan Nation Fisheries Commission, Westbank.
- Burgner, R. L. 1991. Life History of Sockeye Salmon (*Oncorhynchus nerka*). L. Margolis, editor. Pacific Salmon Life Histories. UBC Press, Vancouver.
- Butler, M. J. 1988. In Situ Observations of Bluegill (*Lepomis macrochirus*) Foraging Behavior: the Effects of Habitat Complexity, Group Size, and Predators. *Copeia* 4:939-944.
- Fraser, J. M. 1978. The Effect of Competition With Yellow Perch on the Survival and Growth of the Planted Brook Trout, Splake, and Rainbow Trout in a Small Ontario Lake. *Transactions of the American Fisheries Society* 107(4):505-517.
- Hamilton, J. G., and P. M. Powles. 1979. Feeding habits and growth of young-of-year largemouth bass (*Micropterus salmoides*) near its northern limit, Nogies Creek, Ontario. *Canadian Journal of Zoology* 57:1431-1437.
- Hodgson, J. R., C. J. Hodgson, and S. M. Brooks. 1991. Trophic Interaction and Competition Between Largemouth Bass (*Micropterus salmoides*) and Rainbow Trout (*Oncorhynchus mykiss*) in a Manipulated Lake. *Canadian Journal of Fisheries and Aquatic Sciences* 48:1704-1712.
- Keast, A. 1985. Planktivory in a Littoral-Dwelling Lake Fish Association: Prey Selection and Seasonality. *Canadian Journal of Fisheries and Aquatic Sciences* 42:1114-1126.
- Knight, R. L., and B. Vondracek. 1993. Changes in Prey Fish Populations in Western Lake Erie, 1969-88, as Related to Walleye, *Stizostedion vitreum*, Predation. *Canadian Journal of Fisheries and Aquatic Sciences* 50:1289-1298.
- Koshinsky, G. D. 1972. Preliminary Report No. 5, Partial fulfillment of Task 66, Abstract on "Fish Habitat Survey: Okanagan Tributary Streams, 1969". Pages 20 *in* Canada-British Columbia Okanagan Basin Agreement. Okanagan Study Committee, Penticton.

- Lyons, J. 1987. Prey Choice among Piscivorous Juvenile Walleyes (*Stizostedion vitreum*). *Canadian Journal of Fisheries and Aquatic Sciences* 44:758-764.
- Marrin, D. L., and D. C. Erman. 1982. Evidence Against Competition Between Trout and Nongame Fishes in Stampede Reservoir, California. *North American Journal of Fisheries Management* 2:262-269.
- Matthews, S. 2001. Senior Fisheries Biologist. Ministry of Water, Land and Air Protection, Penticton.
- Mittelbach, G. 1984a. Group size and feeding rate in bluegills. *Copeia* 4:998-1000.
- Mittelbach, G. 1984b. Predation and resource partitioning in two sunfishes (Centrarchidae). *Ecology* 65:499-513.
- Pinset, M. E., et. al. 1974. Fisheries and Wildlife in the Okanagan Basin: Technical Supplement IV. Pages 198pp. *in* Canada-British Columbia Okanagan Basin Agreement, Victoria.
- Porath, M. T., and E. J. Peters. 1997. Walleye Prey Selection in Lake McCnaghy, Nebraska: A Comparison between Stomach Content Analysis and Feeding Experiments. *Journal of Freshwater Ecology* 12(4):511-520.
- Savino, J. F., and R. A. Stein. 1989. Behavior of fish predators and their prey: habitat choice between open water and dense vegetation. *Environmental Biology of Fishes* 24(4):287-293.
- Scott, W. B., and E. J. Crossman. 1998. *Freshwater Fishes of Canada*. Galt House Publications Ltd., Oakville.
- Shepherd, B. G. 1990. Okanagan Lake Management Plan. Pages 87pp *in* Technical Report. Ministry of Environment, Okanagan Sub-Region, Southern Interior Region, Penticton.
- Slipke, J., and W. G. Duffy. 1997. Food Habits of Walleye in Shadehill Reservoir, South Dakota. *Journal of Freshwater Ecology* 12(1):11-17.
- Wahl, D. H., R. A. Stein, and D. R. DeVries. 1985. An Ecological Framework for Evaluating the Success and Effects of Stocked Fishes. Pages 176-189 *in* Fish Stocking Within an Ecological Framework American Fisheries Society Symposium 15, volume 15.
- Webb, R. W. 1986. Effect of Body Form and Response Threshold on the Vulnerability of Four Species of Teleost Prey Attacked by Largemouth Bass (*Micropterus salmoides*). *Canadian Journal of Fisheries and Aquatic Sciences* 43:763-771.

- Weidel, B. C., D. C. Josephson, and C. C. Drueger. 2000. Diet and Prey Selection of Naturalized Smallmouth Bass in an Oligotrophic Adirondack Lake. *Journal of Freshwater Ecology* 15(3):411-420.
- Werner, E. E., D. J. Hall, and D. R. Laughlin. 1977. Habitat Partitioning in a Freshwater Fish Community. *Journal of Fisheries Research Board of Canada* 34:360-370.
- Werner, E. E., Hall, D.J. 1988. Ontogenetic Habitat Shifts in Bluegill: The Foraging Rate-Predation Risk Trade-Off. *Ecology* 69(5):1352-1366.
- Yako, L. A., and M. E. Mather. 2000. Assessing the Contribution of Anadromous Herring to Largemouth Bass Growth. *Transactions of the American Fisheries Society* 129:77-88.
- Yule, D. L., R. A. Whaley, and P. H. Mavrakis. 2000. Use of Strain Season of Stocking, and Size at Stocking to Improve Fisheries for Rainbow Trout in Reservoirs with Walleyes. *North American Journal of Fisheries Management* 20:10-18.
- Zimmerman, M. P. 1999. Food Habits of Smallmouth Bass, Walleyes, and Northern Pikeminnow in the Lower Columbia River Basin during Outmigration of Juvenile Anadromous Salmonids. *Transactions of the American Fisheries Society* 128:1036-1054.